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THE DEVELOPMENT OF CLASSIFICATION AND MEMORY ABILITY IN ACHIEVING AND LEARNING DISABLED CHILDREN: PIAGETIAN AND LEVELS OF PROCESSING APPROACHES

BY

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled The Development of Classification and Memory Ability in Achieving and Learning Disabled Children: Piagetian and Levels of Processing Approaches submitted by Anna Joan Kirkbride in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Educational Psychology.

ABSTRACT

This study investigated the relationships between the development of five Piagetian classification skills and memory performance on a levels of processing task in which categorization seemed an appropriate strategy for encoding and retrieving information. The sample population included 20 achieving and 20 learning disabled children at four age levels (six to seven, eight to nine, 10 to 11 and 12 to 13 years).

Major findings of the investigation were: (1) both achieving and learning disabled children demonstrated age related stages of development for each classification concept; (2) performance of learning disabled children on the classification tasks was usually inferior to that of their achieving peers; (3) compared to achievers, learning disabled children demonstrated developmental lags of two to four years with respect to the age at which they acquired the concepts of Additive Composition of Classes, Singular Class, Null Class and the Duality Principle; (4) the order of classification task difficulty was similar for achieving and learning disabled children; (5) although the population of learning disabled children was heterogeneous in that both perceptual and verbal deficits appeared to contribute to their academic problems, poor classification skills appeared to be a general characteristic of these children. Classification may be a broad based mental activity which is vulnerable to different types of dysfunction; (6) in both achieving and learning disabled children, memory

appeared to be developmental; (7) total recall of learning disabled children was inferior to that of their achieving peers except in the case of the eight to nine year olds; (8) recall ability of 10 to 11 and 12 to 13 year old learning disabled children lagged two to four years, respectively, behind that of their achieving peers; (9) recall of semantic encodings by children at all age levels was superior to recall of both phonemic and physical encodings (which did not differ); (10) the use of category organization as a mnemonic strategy was reported more frequently by older children than younger children, and more frequently by achieving than learning disabled children; (11) achieving and learning disabled children used category cues efficiently for recall of further information following the spontaneous recall test; (12) generally, as the developmental stage of each classification task increased, the recall scores of achieving and learning disabled children at the stage increased. Highest scores were obtained by children who were concrete operational on the Duality Principle. This finding may reflect the level of cognitive development associated with the generalization of classification concepts and language skills which appears essential for mastery of the Duality Principle. Concrete operational performance was not demonstrated on the Duality Principle until three other tasks were at the concrete operational level; (13) when grouped according to the number of concepts upon which concrete operational performance was demonstrated, achieving and learning disabled children, generally, performed equally well on a memory task in which categorization appeared to be a useful

strategy for encoding and retrieving information; and (14) development of the mnemonic strategy, categorization, appeared to be related to the development of classification concepts.

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CHAPTER 1

INTRODUCTION

The principal concern of the present study was with the relationship which exists between the knowledge that children possess and their memory ability. It is generally accepted that as children grow older their memory ability improves. Consequently, there has been a search for answers to the question: "What is memory development really the development of?" Flavell (1971) has suggested that memory development is largely:

> ... The development of intelligent structuring and storage of input, of intelligent search and retrieval operations and of intelligent monitoring and knowledge of these storage and retrieval operations — a kind of 'metamemory' perhaps.
>
> (p. 277)

The development of memory is linked to the development of intelligence and all the various cognitive abilities and skills that are involved. Memory, according to Flavell, may simply be "applied cognition." A theoretical base for this line of reasoning is found in the writing of Jean Piaget (Piaget, 1968; Piaget and Inhelder, 1973).

> ... The memory in the wide sense ... is a mode of knowledge ... it is not bound up with the immediate data, and unlike intelligence is not involved in the solution of new problems — its special province is the reconstruction of the past ... this reconstruction poses a special problem which the subject cannot solve without reflection, and this is precisely why memory cannot be divorced from the intelligence.
>
> (Piaget and Inhelder, 1973, p. 378).

Piaget (1968) suggests that the activities of the memory and

intelligence are inseparable. According to Piaget, the operations involved in memory processes are derived from cognitive structures which develop in the child during the sensori-motor, pre-operational, concrete operational and formal operational periods of cognitive development. As the logical thought of the child develops and becomes more organized and flexible, the memory functions in a more organized way and the memory ability of the child increases and improves.

The introduction of information processing models of memory has led to remarkable advances in our understanding of how human memory functions. These models tend to emphasize, in varying degrees, two aspects of information processing, structure and process. The structural theories tend to describe the flow of information through a compartmentalized memory system. Specific characteristics of the compartments determine both the manner in which information is processed, and the amount of information processed. The information processing models oriented towards process are chiefly concerned with the processes or strategies which are involved in the encoding, storage, and retrieval of information.

Information processing models of memory were designed to describe the structure of adult memory, not the development of memory. An information processing model of memory, such as the Craik and Lockhart (1972) levels of processing model might, however, provide an excellent instrument with which to study the development of and individual differences in memory, since it would enable the

investigator to relate memory ability to other cognitive processes (Eysenck, 1977; Reese, 1973, 1976; Naus, Ornstein and Hoving, 1978). The work of Geis and Hall (1976), Owings and Baumeister (1979), and several studies conducted at the University of Alberta (Kirkbride, 1978a; Lupart, 1978; Snart, 1979) have indicated that the levels of processing model is useful for investigating the development of memory in children.

Craik and Lockhart (1972) view memory as a continuum, not as a series of structural stores. The analysis of incoming perceptual stimuli or information proceeds through a hierarchy or "series of sensory stages, to levels associated with matching or pattern recognition, and finally to semantic associative stages of stimulus enrichment" (p. 675). The "depth of processing" is related to the degree of "semantic or cognitive analysis" to which information is subjected. The persistence of the memory trace "is a function of the depth of analysis, with deeper levels of analysis associated with more elaborate, longer lasting, and stronger traces" (p. 675). Craik and Lockhart designate three levels of analysis, ranging from early physical analysis to phonemic analysis to later semantic analysis of the features of incoming stimuli.

Craik and Lockhart suggest, that on a test of recall for words processed at physical, phonemic and semantic levels, the hierarchy of recall will be semantic > phonemic > physical. Experiments by Craik and Tulving (1975) substantiated the predicted hierarchy.

The major emphasis of the levels of processing approach is on the encoding of information. Consideration of the encoding process

involves consideration of the strategies used to put information into memory. Hagen, Jongeward and Kail (1975) suggest that the "better memory," of older children compared to younger children, can be attributed not to an increase in the structural capacities of older children's memories, but to a more efficient use of their memory capacities. More efficient use of memory capacity involves, in part, more "active, flexible and organized" use of simple mnemonic strategies such as verbal labeling and cumulative rehearsal and more elaborate strategies such as categorization.

Flavell (1970) noted that memory deficits may be associated with the absence of mnemonic strategies in children, and with children's inability to spontaneously use such strategies even when they are present. Flavell's findings are provocative, and intuitively lead to the question of where memory strategies originate and how they develop.

Some developmentalists (Brown, 1975; Flavell, 1971; Reese, 1973, 1976) have proposed that the development of memory strategies could be studied by merging an information processing model of memory with Piaget's theory of intellectual development. The mnemonic strategies are interpreted as structured cognitive operations. Reese (1976) suggests that two aspects of the Craik and Lockhart (1972) levels of processing model: (1) the hierarchy of operations and (2) the omission of distinctions between structural stores make it useful to study the development of memory.

Recently, Brown (1979) has argued that three common features emphasized by levels of processing models of memory and

developmental models (whether the orientation of the latter is European, i.e., Piaget (1970); American, i.e., Brown (1975); or Russian, i.e., Vygotsky (1962) and Yendovitskaya (1971)) make them compatible for research purposes. The common features discussed by Brown (1979) are: (1) the concept of voluntary versus involuntary memory; (2) the notion that what is remembered depends upon the activity of the subject; and (3) the process of "head fitting." By "head fitting" Brown means ... "there is an intimate relation between what is known and what can be known, and because we must come to know more with increasing age and experience, there must be a close correspondence between what a child can understand at any point in life and his or her concurrent cognitive status" (p. 250).

The present investigation attempted to relate the performance of children on a levels of processing memory task to one aspect of intellectual development described by Inhelder and Piaget (1964), namely classification. Classification involves the ability to organize objects or events into rational or logical groups, and to understand the inclusion relations between the groups in a class hierarchy. The development of classification is, in Piaget's view, a crucial factor in the growth of the logical thinking in the child.

The author's decision to look for links between performance of children on a levels of processing memory task and the operative level of development of their classification concepts was guided by the following rationale with respect to the tasks involved. A levels of processing task (Kirkbride, 1978a; Lupart, 1978) presents

the child with a series of thirty orienting questions and thirty stimulus words. The stimulus words represent six categories of familiar items (fruit, weapons, furniture, vegetables, clothing, and vehicles). The orienting questions induce the child to process the stimulus words to one of several levels of processing: a physical level, the question is related to the physical characteristics of the word, i.e., Does this word start with a "G"? ... GUN; a phonemic level, the question is related to the rhyming characteristics of the word, i.e., Does this word rhyme with shed? ... BED; and a semantic level, the question is of a categorical nature i.e., Does this word mean a type of fruit? ... PEACH.

According to Craik and Lockhart (1972), when words are processed at the semantic level, the individual makes use of rules and past knowledge. Information is assimilated to "existing cognitive structures." Given the question: "Is this word a type of fruit?", and the stimulus word,"Peach," the writer would hypothesize that classification concepts are essential to the child's proper response. The cognitive structure to which the child assimilates the information may be the classification structure which, according to Piaget, originates in the sensori-motor activities of the child and develops during the pre-operational, concrete operational and formal operational periods of intellectual development.

To decide whether or not a peach is a fruit, the writer contends that the child must consider the properties of the "class" of fruit and the "class" of peach. The better the child understands classes and sub-classes, the more meaningful the encoding

will be. Classification schemata will be used at the time of encoding. According to Piaget and Inhelder (1973), the schemata used to retrieve information from memory are the same schemata that are used to put information into memory. If, as Piaget suggests, the development of the operational structure of classification leads to reversible thinking in the child, it is quite possible, that at the time of recall, the child will "turn round on" the reasoning used to put information into memory, in order to retrieve information from memory.

Craik and Tulving (1975) also stress the importance of mental activity or mental operations in levels of processing models of memory ... "items are remembered not as presented stimuli acting on the organism, but as components of mental activity. Subjects remember not what was out there, but what they did during encoding" (p. 292).

If a child recalls more semantic level words on the levels of processing memory task described here, perhaps it is because a meaningful classification process was involved at the time of encoding and gave rise to a more durable trace. The child may be remembering not only the word, but also the process used for encoding. If classification procedures used at the time of semantic processing are recalled, the child may use category cues to search for words stored in memory that were processed at shallower phonemic and physical levels.

The work of Flavell and his colleagues (Flavell and Wellman, 1977; Kreutzer, Leonard and Flavell, 1975) with respect to

metamemory suggests that children know something about how their memories work. Children's classification and metamemory skills may contribute to their performance on the levels of processing task discussed here.

The investigation described in this thesis was a comparative research study. The sample population included achieving and learning disabled children at four different age levels (six to seven, eight to nine, 10 to 11 and 12 to 13 years.) For the purpose of the study Koppitz's (1971, 1977) very comprehensive definition of the learning disabled child was selected. Koppitz described the learning disabled child as being unable to benefit from the regular school program despite normal intellectual potential, being more than one year below his/her mental age in school achievement, and exhibiting no gross motor impairment. Factors cited by Koppitz to account for the learning disability included: immaturity or developmental lag, perceptual problems, neurological impairment, severe early deprivation, genetically determined cerebral dysfunction, emotional disturbance and minimal brain dysfunction. The Koppitz definition is an "umbrella" definition that covers a very heterogeneous population of children. There is, however, no single cause of learning disability.

Educators freqently find that many learning disabled children experience memory difficulties. Recently, Koppitz (1977) has stressed that poor intersensory integration, sequencing and recall are major factors associated with the inadequate performance of long-term special class pupils.

Reviewing studies conducted to assess the memory performance of learning disabled children and to compare their memory performance with that of normal peers, Hallahan (1975) reports that little definitive information is available to indicate whether poor memory performance, when it occurs in learning disabled children, is due to perceptual problems, i.e., inability to recognize and discriminate auditory and visual stimuli; capacity deficiencies with respect to structural systems such as short-term memory; or to process variables such as the absence or inefficient use of mnemonic strategies. Torgesen (1978, 1980) and Torgesen and Kail, Jr. (1980) have recently stressed the importance of language problems and the inefficient use of appropriate task strategies with respect to the poor memory performance of learning disabled children.

Studies by Kirkbride (1977, 1978a) suggest that learning disabled children lag behind their achieving chronological age peers with respect to the development of classification concepts and performance on a levels of processing memory task. Kirkbride (1977) studied the development of Piagetian logico-mathematical concepts (conservation, classification, seriation) in achieving and learning disabled children at two different age levels, one younger than nine years six months and one older than nine years six months. The classification skills assessed in this investigation were more poorly developed in learning disabled children than in achieving children at the same age level. (Details of this study are given in Chapter 11).

Kirkbride (1978a) administered a levels of processing task to groups of ten achieving and ten learning disabled children, at each of three different age levels, i.e., eight to nine years, 10 to 11 years, and 12 to 13 years. Results indicated that in both the achieving and learning disabled groups, memory was developmental in nature. The total recall performance of achieving children was superior to that of learning disabled children (p=.05). Interviews with children following the recall test indicated that achieving children consciously used category cues for the retrieval of information more frequently than learning disabled children. (Details of this study are given in Chapter III).

A pilot investigation was carried out by Kirkbride (1978a) to compare the development of classification skills in young children with their performance on a levels of processing memory task. Achieving and learning disabled children at each of four age levels (six to seven, eight to nine, 10 to 11 and 12 to 13 years) participated in the study. The test battery included five Piagetian classification tasks and a levels of processing task.

Graphic representation of the pilot study data indicated some interesting trends. Total recall of children with well developed classification skills was superior to that of children with less well developed classification skills. With respect to performance on both the classification and memory tasks, achieving children were superior to learning disabled children at the same age level. (Details of the investigation are given in Chapter V).

Consideration of the theoretical concepts, research findings,

and the results of the author's own investigations outlined in this chapter led to the design and completion of a full scale comparative research study. The study was aimed at the investigation of the relationship between the level of development of classification skills in and performance on a levels of processing memory task by achieving and learning disabled children at four different age levels.

Before presentation and discussion of the results of this study, the following chapters will summarize: Piaget's theory of the development of classification and selected relevant research (Chapter II); memory theories and research related to the study (Chapter III); and theories and research relevant to the relationship between operativity and memory (Chapter IV).

CHAPTER II

PIAGET'S THEORY OF CLASSIFICATION AND SELECTIVE REVIEW OF RELATED RESEARCH

Cognitive development, the growth of logical thinking, and the development of classification and seriation skills are integrally bound together in Piagetian theory. Classification involves the ability of the child to organize objects or events into rational or logical groups, and to understand the inclusion relations which exist between groups and subgroups in a hierarchical classification. Seriation involves the ordinal relations which exist between classes and the recognition of such concepts as "less than" and "greater than." Reasoning ability grows out of the activities which are involved in the child's abstraction of the criteria of a classification and the coordination of the relations "less than" and "greater than." The development of the structures of operational classification and seriation, contributes to the growth of logical thinking processes in the child. The essential role of seriation in the development of logical thinking is recognized and accepted by the writer. This investigation, however, was concerned with classification and seriation will not be discussed here.

The Development of Classification

The classification system of the child originates in sensorimotor activity (Piaget, 1952; Inhelder and Piaget, 1964). Prior to language acquisition, behavior patterns which suggest classification can be observed in children. For example, given a familiar object, the young child can immediately recognize a number of

possible uses, and assimilates the object to various schemata of shaking, rocking, throwing, etc. This same child, given an unfamiliar object, will submit it to a succession of familiar schemata in an attempt to discover its use. The child's actions in relation to objects represents a practical, rudimentary classification (Inhelder and Piaget, 1964).

According to Inhelder and Piaget (1964), the development of classification proceeds through three distinct stages. An initial pre-operational stage of graphic collection is followed by a quasi-classificatory stage of non-graphic collections. Operational classification is achieved when the child is able to construct a genuine hierarchical classification and to understand the inclusion relations which exist between different levels of the hierarchy. Mastery of class inclusion principles requires an understanding of the permanent inclusion of the parts in the whole and the use of the operational quantifiers "all" and "some."

Criteria for Operational Existence of Classes

The criteria necessary for the operational existence of classes are: "(1) The subject can give an intensive definition of a class in terms of a more general class and one or more specific differences. (2) He can handle their extension in accordance with the structure of inclusion, as shown by his mastery of quantifiers 'all,' 'some,' 'one' and 'none'" (Inhelder and Piaget, 1964, p. 7). The following definitions have been provided by Inhelder and Piaget to describe these properties of classes.

1. Intension: The intension of a class is the set of properties

common to the members of that class together with the set of differences which distinguish them from another class. For example, a large blue square and a small red square both share the property of squareness. The intension or defining property of the class is squareness.

2. Extension: The extension of a class is the list of members that belong to the class. The defining property or intension of the class determines what objects will be placed in it. For example, a large blue square and a small red square would both be placed in the class of squares. Intension defines extension (Ginsburg and Opper, 1969).

3. Intensive quantification: Intensive quantification involves the use of the operational quantifiers "all," "some," "one" and "none." The statement "All A are B" implies that there are more B than A but the actual quantitative relationship between A and A' is not specified (where A' = B - A). For example, the statement "All red squares (A) are squares (B)" implies that there are more squares (B) than red squares (A). The actual quantitative relationship, however, between red squares (A) and squares not red (A') is not specified (where squares not red (A') = squares (B) - red squares (A)).

4. Class inclusion: The condition of class inclusion is satisfied only when both of the following propositions are understood and accepted: (1) All A are some B and (2) A is less than B, i.e., $A < B$. For example, (1) All of the class of red squares (A) are some of the class of squares (B); and (2) the class of red squares

(A) is less than the class of squares (B).

The child actively constructs his own system of operational classification. Inhelder and Piaget recognize the importance of maturation, perceptual factors and language with respect to the development of classification. They insist, however, that the actions of the child are crucial factors which determine the development of classification. The following is a summary of Inhelder and Piaget's description of the sequence of stages through which a child proceeds in developing a class system.

Stage 1: Graphic Collections

At the stage of graphic collections the child cannot construct genuine classes because he cannot differentiate between or coordinate intensive and extensive properties of classes. The intensive properties involve relations of similarity and difference while the extensive properties involve class inclusion relations. Sensori-motor schemas allow the child to "see" similarities between objects and to gather collections on the basis of these similarities (Flavell, 1963). The child, however, applies the relations of similarity and difference to the objects by a process of "successive assimilations," that is, to successive pairs of objects and not to all of the elements simultaneously (Inhelder and Piaget, 1964). Successive assimilations lead the child to consider the pattern of his arrangement and other descriptive properties of the material. Sorting is not planned and the criterion of classification tends to shift as new objects are added to the collection. Essentially what are seen at the stage of graphic collections are

spatial arrangements of the elements to be classified.

Successive assimilations prohibit the proper use of the operational quantifiers all and some which is essential for mastery of class inclusion. The young child cannot unite "all" the elements having a common property to produce a simultaneous whole. It is even more difficult for the child to deal with "some" as a subclass.

The child at the stage of graphic collections fails to understand that a supraordinate class (B) will always contain more elements than either (A) or (A'). Piaget (1952) demonstrated this dilemma in children with his classic "beads" experiment. The child was shown a box containing twenty wooden beads of which eighteen were brown and two were white. After establishing that the child knew that the beads were all wooden, and were of two colors, brown and white, the child was asked which of the two necklaces would be longer — one made from the wooden beads or one made from the brown beads? A child at the stage of graphic collections always answers "the brown necklace" and will not be convinced otherwise even after he has made the necklaces and compared them.

$$\begin{tikzcd}[column sep=small] & \text{B (wooden beads)} \arrow[dl] \arrow[dr] & \\ \text{A (brown beads)} & & \text{A' (white beads)} \end{tikzcd}$$

In Piagetian terms, the child fails to grasp B (wooden beads) = A (brown beads) + A' (white beads). This is the operation of addition of classes. Also the child does not understand that A (brown beads) = B (wooden beads) - A' (white beads). This is the

operation of substraction of classes. Consequently, the child does not realize A (brown beads) < B (wooden beads). At the stage of graphic collections, the child's thinking is irreversible. This means, according to Piaget, that the child cannot simultaneously think of the whole class B (wooden beads) and its parts A (brown beads) and A' (white beads). Immediately that attention is directed to the parts, the child loses sight of the whole and tends to compare the parts with each other.

Stage II: <u>Non-graphic Collections</u>

Piaget has characterized the stage of non-graphic collections as a quasi-classificatory stage. The child is able to form groups on the basis of relations of similarity and difference and can divide a supraordinate class B (wooden beads) into its subclasses A (brown wooden beads) and A' (white wooden beads). Often the child seems capable of true classification, but class inclusion relations have not yet been mastered.

When presented with the "beads" task and asked which of two necklaces, the wooden bead necklace or the brown bead necklace, is longer, the child at this stage will initially answer, incorrectly, that the brown necklace is longer. Only after constructing the necklaces does the child discover that the wooden bead necklace is longer.

Inhelder and Piaget (1964) suggest, that at the stage of non-graphic collections, the child can connect the subcollections A (brown beads) and A' (white beads) with the whole collection B (wooden beads) provided that the parts are united, i.e., A (brown

beads) + A' (white beads) = B (wooden beads). Once the parts are dissociated either in space or in thought the child no longer associates them with the whole. The child fails to grasp the operation, A (brown beads) = B (wooden beads) - A' (white beads). According to Piaget, an operation is always reversible and he argues that since the inverse operation A = B - A' does not exist for the child, then A + A' = B cannot exist at Stage II as a direct operation, no matter how much it may resemble one. "It is in fact no more than intuitive union because it is contingent upon a temporary differentiation of the collection (B) into the sub-collections (A) and (A')" (Inhelder and Piaget, 1964, p. 50).

The problems experienced by children at the stage of non-graphic collections in applying the logical quantifiers all and some to classes were demonstrated by Inhelder and Piaget. Children were presented with a series of shapes consisting of two red squares, two blue squares and five blue circles. The squares were interspersed among the circles. The possible hierarchies were:

$$\begin{tikzcd} & \text{B (blue objects)} \arrow[dl] \arrow[dr] & \\ \text{A (blue circles)} & & \text{A' (blue squares)} \end{tikzcd}$$

and

$$\begin{tikzcd} & \text{B (squares)} \arrow[dl] \arrow[dr] & \\ \text{A (red squares)} & & \text{A' (blue squares)} \end{tikzcd}$$

Two forms of questions were asked:

1. Are all the Bs A?

   i.e., Are all the blue ones circles?

2. Are all the As B?

   i.e., Are all the circles blue?

Inhelder and Piaget suggest that the young child tends to think both questions are asking whether A and B are of identical extension, i.e., if A (blue circles) = B (blue objects). This interpretation leads the child to answer question 1, "Are all the blue ones circles?" correctly. By comparing the extension of B (blue objects) and A (blue circles) the child concludes that not all B (blue objects) are A (blue circles) because there are some blue squares. The false assumption that question 2, "Are all the circles blue?" is asking if A (blue circles) = B (blue objects) leads the child to answer incorrectly. By comparing the extension of A (blue circles) and B (blue objects), the child answers: "No, because there are also some blue squares."

Piaget believes that the child's inaccurate thinking in this situation is due to a failure to distinguish between "included in" and "equals," a failure to recognize that "all" of the A (blue circles) correspond to "some" but not "all" of the B (blue objects). The class inclusion operation A (blue circles) = B (blue objects) - A' (blue squares) is not present in the child's thought. When the child focuses his attention on the whole B (blue objects), he realizes that A (blue circles) + A' (blue squares) = B (blue objects), but when attention is focused on the part A (blue circles), the whole is momentarily lost from thought and the child

does not realize A (blue circles) = B (blue objects) - A' (blue squares) and consequently compares the parts with each other. Thinking is still irreversible. In summary, the child understands inclusion when he is capable of grasping that all the As (blue circles) are some of the Bs (blue objects). The child does not understand inclusion when he interprets the statement that all the As (blue circles) are Bs (blue objects), as equivalent to, all the As (blue circles) are all the Bs (blue objects).

Stage III: Genuine Operational Classification

The achievement of operational classification becomes possible with the complete mastery of class inclusion relations. The intensive and extensive properties of classes are differentiated and coordinated, part-whole relationships are fully understood and the child no longer experiences difficulties with the logical quantifiers "all" and "some." The thought of the child is at last reversible. The equations A + A' = B, and A = B - A' can be considered simultaneously. Both the direct and inverse operations can be effected.

Processes Underlying the Development of the Structure of Operational Classification

Through all his investigations Piaget sought to discover and describe the basic processes which underly the development of the structure of operational classification. Piaget has described, for example, the logical operations involved in the child's cognition of simple class hierarchies, i.e., the primary addition of classes.

Flowers (C) Other Things (C')

Tulips (B) Other Flowers (B')

Yellow Tulips (A) Other Tulips (A')

In the hierarchy illustrated above, A, B, and C represent primary classes: A', B', and C' are secondary or complementary classes. For example, A represents the primary class of yellow tulips, the secondary class A' is a "multiclass denotation" (Flavell, 1963) and refers to all the classes of tulips except yellow tulips, i.e., red tulips, white tulips, pink tulips, etc. Each class is considered as an element of the system.

The child can apply a combining (+) operator to the elements of the system, but it can only be applied to two elements at a time. According to Piaget (see Flavell, 1963 and Ginsburg and Opper, 1969), five properties describe how the child can apply the binary operator to the elements. The properties are:

1. Composition: The child can unite subclasses to form supraordinate classes.

   A (yellow tulips) + A' (other tulips) = B (tulips)

2. Associativity: The child can combine classes in different orders and obtain equivalent results.

   A (yellow tulips) + B (tulips) = B (tulips)

   and then

   B (tulips) + C (flowers) = C (flowers)

or alternatively

A (yellow tulips) + (B (tulips) + C (flowers)) = C (flowers)

3. Identity: Identity refers to the "nothing" element which is present in the hierarchical system. When the child combines the "nothing" element with other elements, no change takes place. A (yellow tulips) + "nothing" element = A (yellow tulips).

4. Negation: Negation implies that for every element in the system there is another element (the inverse) which, when combined with the first, produces the "nothing" element. A (yellow tulips) + (-A)(inverse of yellow tulips) = "nothing" element.

5. Special identities: Two aspects of special identities are tautology and resorption. Tautology involves the combination of a class with itself to yield no change, i.e., A (yellow tulips) + A (yellow tulips) = A (yellow tulips). Resorption involves the combination of a class with the next highest class in the hierarchy, i.e., A (yellow tulips) + B (tulips) = B (tulips).

In summary, the properties of composition, associativity, identity, negation and special identities describe, according to Piaget, everything the child can do with a simple class hierarchy. The processes are integrated, they do not stand alone (Ginsburg and Opper, 1969).

Complementary Classes

Inhelder and Piaget (1964) suggest that understanding of class inclusion relations is "logically prior" to the understanding of complementary classes. Under the general heading of complementary classes, Inhelder and Piaget discuss a variety of topics: primary and secondary classes, the negation of classes, the singular class, the null class, and the Duality Principle. These topics were of particular importance with respect to the investigation described here and will be discussed individually.

Primary and Secondary Classes

In a typical explanation of the relationships which exist between primary and secondary (complementary) classes, Inhelder and Piaget refer to a class hierarchy in which B represents a primary class of flowers and A represents a primary class of tulips. The relationship between B (flowers) and A (tulips) is represented as A (tulips) + A' (other flowers) = B (flowers). The primary classes of B and A refer to single classes, i.e., flowers and tulips. The secondary class A' is a "multiclass denotation" (Flavell, 1963) and refers to an unspecified number of classes which are of the same rank as the corresponding class A (tulips). The child's understanding of primary and secondary classes is determined by class inclusion principles and is marked by sequential progression through three developmental stages: graphic collections, non-graphic collections, and concrete operations.

Negation of Classes

A number of experiments were conducted by Inhelder and Piaget

(1964) in order to determine exactly what negation of classes meant to children. Given a hierarchy of primary classes such as E > D > C > B > A, i.e., animals > mammals > canines > dogs > spaniels, how does the child think about the secondary class A' (the things not -A, the things not spaniels)? Does not -A (not spaniels) represent for the child the complement of A (spaniels) with respect to everything, with respect to the next larger class B (dogs) or with respect to a class intermediate in the hierarchy such as C (canines)?

Inhelder and Piaget (1964, p. 140) concluded that in a hierarchical system of class inclusions, there are two types of negation which have a general meaning: negation with respect to the whole, i.e., not -A in the absolute sense; and negation with respect to the next including class (which gives the secondary class A' = B - A). The child's understanding of negation of classes was attributed to the orderly development of class inclusion relations.

The Singular Class

According to Inhelder and Piaget (1964), the concept of the singular class is closely linked to the idea of complementary classes and represents an important aspect of general classificatory behavior. Although young children do not have great difficulty in selecting the "unique specimen", i.e., the one that is different, from an array of like objects, they do experience great difficulty in recognizing that a set containing a single element can form a class or "intuitive collection."

The construction of singular classes by children and the effect of numerical disproportion on such classification were studied by Inhelder and Piaget. The subject was presented with a collection of items consisting of four large blue squares, four small blue squares, three large blue circles, four small blue circles, and one large red circle. The experimenter kept three red objects (a large square, a small square and a small circle) on hand to be added later. The child was asked to form classes from the materials that had been provided. The crucial question for Inhelder and Piaget was, would the child use color as a criterion for sorting, because in doing so he would construct a singular class.

Three stages of development in relation to the construction of singular classes were identified. Children at Stage 1 tended to treat the "unique element," i.e., the large red circle, like the rest of the objects neglecting its special property, i.e., red. In some cases the red circle was ignored completely. Children at Stage 2 spontaneously produced a classification based on color only after the additional red elements were presented and not before. Children at both Stage 1 and Stage 2 refused to construct a singular class or collection because "classifying consists of constructing collections, and a single red circle cannot form a collection" (Inhelder and Piaget, 1964, p. 128). At stage 3, children spontaneously sorted all the blue objects into one class and the single red object into another. The concrete operations related to construction of singular classes are established and "complementarity

overrides numerical extension." To construct singular classes children must understand class inclusion relations.

The Null Class

The entire logic of classes cannot be formulated by the child at the concrete operational stage. Inhelder and Piaget (1964) have placed the concept of the null class, the complementary class with no objects, at the borderline between concrete and formal operational thought. Concrete operations are applied directly to objects, and since the null class contains no objects, Inhelder and Piaget asked whether the child would consider the null class to be on "a par with other classes."

Children were given a number of square, round and triangular shaped cards; some of the cards had pictures on them and some of them were blank. First, a spontaneous classification of the cards was requested, and then a dichotomy. According to Inhelder and Piaget, if the child understood the notion of the null class, he divided the cards into a group with pictures on them and a group of blank cards.

Observation of the sorting of cards by the children led to the identification of four developmental stages. At Stage 1, the child formed graphic collections from the cards; at Stage 2, the child formed non-graphic collections from the cards, sorting them on the basis of shape or color (the blank cards were considered to be white cards); at Stage 3, the stage of concrete operations, the child could be led to produce a proper dichotomy with the help of the examiner; at Stage 4a, the beginning of formal operational

thought, the child independently produced a division of the cards to yield a group of cards with pictures on them and a group of cards with no pictures on them (blanks). Children younger than 10 or 11 years tended to avoid making a dichotomy of blank and picture cards.

The concept of the null class is a very sophisticated idea. Piaget has stated that the null class contains no objects, and one cannot help but question whether it is indeed possible to test for such a concept using concrete manipulative materials. As Donaldson (1960) has justifiably argued, the cards represent a class without property, "cards which have no pictures," but since the cards exist there is no null class.

The Duality Principle

Inhelder and Piaget (1964) suggest that a duality exists between the ordering of classes and the ordering of their complements, the relationship may be expressed: $A < B \longrightarrow \text{not} - A > \text{not} - B$.

$$\begin{tikzcd} & & C \text{ (living things)} \arrow[dl] \arrow[dr] & \\ & B \text{ (animals)} \arrow[dl] \arrow[d] & & B' \text{ (not-animals)} \\ A \text{ (birds)} & A' \text{ (not-birds)} & & \end{tikzcd}$$

The child at the stage of concrete operations is very knowledgeable about the above class hierarchy. The child understands:

1. The reversibility of operations: a situation which involves negation or inversion whereby one operation is

cancelled out by a second operation.

B (animals) = A (birds) + A' (not-birds) direct operation

A (birds) = B (animals) - A' (not-birds) inverse operation

2. The reciprocity of relations: a situation in which the combination of direct and inverse operations leads to an equivalence, not to a cancellation.

   B (animals) > A (birds)

   A (birds) < B (animals)

3. The concrete operational child also understands the relationship which exists between the class of birds and its complementary class of not-birds. The child knows that not-birds is a multiclass denotation which includes all the classes of animals (dogs, cats, horses, etc.) which, when combined with the class of birds, exhausts the contents of the supraordinate class, animals.

At the concrete operational stage the operations of negation and reciprocity have been isolated from each other. In the Law of Duality, negation and reciprocity are integrated into a single system, and this synthesis is a characteristic of formal operational reasoning (Inhelder and Piaget, 1964). The symmetrical relationship between classes and their complementary classes are not understood by the child until the appearance of formal operations.

living things	animals	birds

Not-birds > not-animals

Not-birds = animals + rest of living things

Not-animals = rest of living things

The child at the stage of formal operations understands:

animals > birds = not-birds > not-animals

The procedure devised by Inhelder and Piaget to test for understanding of the Duality Principle involved the presentation of pictures of animals which had to be divided by successive dichotomies into birds and other animals and then ducks and other birds. Responses to a series of questions related to the three level class hierarchy were requested from the subjects. The questions dealt with the negation of classes, i.e., "If all the ducks in the world were killed, would there be any birds left?"; the inclusion of classes, i.e., "Are there more birds or more animals?"; and the Duality Principle, i.e., "Show me all the things that are not-ducks and all those that are not-birds" and then — "Are there more living things which are not-ducks or more living things which are not-birds?"

Four developmental stages were identified. At Stage 1, the subject was able to sort the classes ducks, birds not ducks, and animals not birds, but could not answer any of the questions correctly. At Stage 2, the subject could sort the classes and answer the questions dealing with negation of classes. At Stage 3,

the concrete operational stage, the subject could sort the classes and answer the questions dealing with negation of classes and quantification of inclusion. At Stage 4, the formal operational stage, the subject answered all the questions properly and solved the Duality Principle.

Research Related to the Development of Classification

The questions raised with respect to the development of classification by this investigation were primarily concerned with: (1) the operational stages of classification development and the order in which children acquire classification concepts; (2) class inclusion principles associated with the child's understanding of class hierarchies; and (3) the development of classification skills in learning disabled children.

Research Related to the Operational Stages of Performance and the Sequential Acquisition of Classification Concepts

Numerous studies have replicated and validated Inhelder and Piaget's (1964) original experiments and described pre-operational, intuitive and concrete operational stages of behavior with respect to the development of various classification concepts in young children. Age related stages of classificatory behavior, similar to those proposed by Inhelder and Piaget, have been reported for free classification (Annett, 1957; Frith and Frith, 1975; Kofsky and Osler, 1967); class inclusion (Dodwell, 1962; Elkind, 1961; Garrettson, 1971; Robinson, 1975); and multiplicative classification (Overton and Jordan, 1971; Parker and Day, 1971; Siegel and Kresh, 1971; Lovell, Mitchell and Everett, 1962).

A fundamental assumption of Piaget's theory of the child's construction of a class system is that of a sequential acquisition of classification concepts. The increasing ability of the child to use complex logical operations is the key factor which determines the order in which classification concepts are mastered.

One of the most extensive studies carried out to obtain information regarding the order of difficulty of classification tasks and to determine whether the order of development of classification concepts is the same for all learners is that of Kofsky (1966). Since the present investigation was particularly concerned with the order of difficulty of classification tasks with respect to achieving and learning disabled children, the Kofsky study will be summarized in some detail here. Based upon her interpretation of Inhelder and Piaget's (1964) theory, Kofsky (1966) hypothesized that eleven consecutive steps mark the child's progress to a complete understanding of hierarchical classification and the inclusion relations which exist between different levels of the hierarchy.

Seven concepts, described by Kofsky, were related to the construction of the class hierarchy: (1) resemblance sorting, the child groups two objects together because they are alike in some way; (2) consistent sorting, the child groups more than two objects; (3) exhaustive sorting, the child extends his grouping to all the objects he considers to be equivalent in some way; (4) conservation, the child relies less on physical proximity as a criterion for grouping because he realizes that such groups are

transitory; (5) multiple class membership, the child recognizes that objects can belong to more than one class; (6) horizontal classification, the child groups objects on the basis of different attributes; and (7) true hierarchical classification, the child selects single attributes and then combinations of these attributes as the criteria for grouping.

Kofsky also described a group of four concepts related to the child's understanding of class inclusion. These concepts involved: (1) the use of the logical quantifiers "all" and "some;" (2) the addition of classes to form a supraordinate class (A + A' = B); (3) the more difficult subdivision of the supraordinate class into its component parts (B - A' = A); and (4) the realization of the reversibility of the operations (A + A' = B) and (B - A' = A), and the understanding that B is always greater than A, i.e., (B > A), leads to the mastery of the class inclusion principle. Kofsky's predicted sequence of development of classificatory skills is given in Figure 1.

The "steps" of the developmental sequence were translated by Kofsky into experimental tasks. The tasks were administered to 122 children aged four to nine years. An attempt was made to determine: (1) that the order of difficulty of these tasks corresponded to the developmental sequence described by Piaget (as interpreted by Kofsky); and (2) that children who had acquired a rule at a given point in the sequence had mastered all of the preceding rules. Results of a scalogram analysis of Kofsky's data indicated:

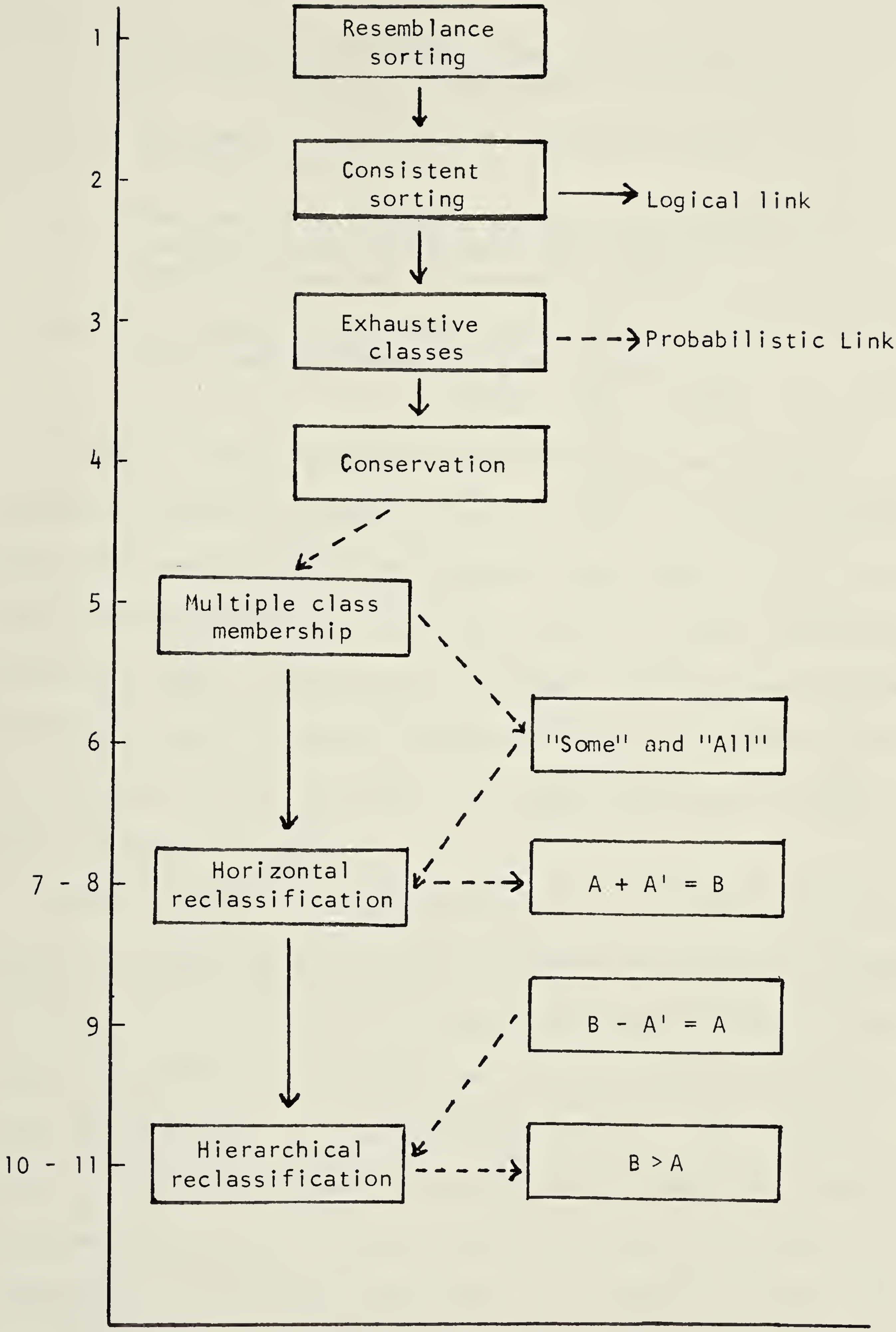

Figure 1. A predicted sequence of classification skill development (Kofsky, 1966, p. 194).

(a) There was a significant correlation between S's age and number of tasks mastered;

(b) the order of difficulty corresponded to the predicted order;

(c) there was no set order of mastery such that the passage of a more difficult item invariably implied passage of all the easier items;

(d) for each task there was no age difference among Ss who made different kinds of errors.

(Kofsky, 1966, p. 191).

Kofsky's results indicated that individuals vary in the sequence of mastery of cognitive tasks. Kofsky's findings and the predictions she made about the sequential development of classification abilities have been criticized in the literature (Langford and Berrie, 1974). Perhaps one of the most creditable explanations of Kofsky's results and the problems which she encountered in her investigation is that of Flavell (who supervised Kofsky's (1966) work) and Wohlwill (1969).

Flavell and Wohlwill considered the issue of whether children acquire all cognitive structures in an invariant sequence or whether the order of acquisition differs among individual children. They suggest that the most unambiguous way to state the relationship which exists between two cognitive acquisitions A and B, which emerge in the order A then B, is to say that A enters the child's competence prior to B. The only way to infer what is in the child's competence, i.e., what the child knows, is to measure the overt products of the child's performance and this involves numerous difficulties. Flavell and Wohlwill introduced the notion of viewing

Piaget's stage theory in terms of a competence-performance model not too unlike the linguist's competence-performance model of language development (Chomsky, 1964). Knowledge of a concept may exist in competence even though that knowledge may not be manifested in performance.

Flavell and Wohlwill believe that an invariant order of emergence is associated with "implicative mediation" relationships. For example, consider two cognitive acquisitions A and B, which emerge in the order A then B. First, A develops and then at a later stage B develops. The performance of B implies the performance of A, because A by definition is part of B. At some time during development, the young child will be capable of A but not B. At no time, however, will the child be capable of B and not A.

This is the type of relationship, according to Flavell and Whohlwill, that exists between the concrete operations and formal operations postulated by Piaget. Since the concrete operations serve as the objects of formal operations, the child who has not constructed the concrete operations related to a given concept, could never be capable of formal operational thinking related to that same concept. If two cognitive acquisitions A and B are predicted to emerge in a fixed order for all children, investigators will want to test the prediction. This situation arose in the Kofsky (1966) investigation.

With respect to the developmental acquisition of classification skills, Flavell and Wohlwill (1969) suggest that Kofsky's (1966) prediction of the order of emergence of some pairs of skills

was empirical and could have been wrong. Other pairs of skills, however, may well have been associated by the "implicative mediation" relationship described above.

> ... For example, she (Kofsky) tested the prediction that children would acquire the ability to group two like objects together before they acquired the ability to recognize that such grouping should be exhaustive, i.e., that each and every object possessing the common attribute should be put in the same pile — none should be left apart and unclassified. But it now seems clear that no empirical data could possibly contradict this hypothesis, because being able to think of putting all the red objects on the table together in a pile logically implies that one can think of putting some of them together, while the converse does not hold. Any empirical deviations from this logically necessary sequence have to be attributable to measurement error or other difficulties.
>
> (Flavell and Wohlwill, 1969, pp. 86-87).

Kofsky (1966) concluded that the best picture of development may not be obtained with the scalogram model. The model is based "on the assumption that an individual can be placed on a continuum at a point that discriminates the exact skills he has mastered from those he has never been able to perform" (p. 202). Scalogram techniques are stringent and do not allow for the competence-performance aspect of development described by Flavell and Wohlwill (1969).

Children are no doubt capable of a broad range of behavior. Their ability to demonstrate understanding of particular concepts is probably influenced by a number of factors present in the actual test situation. The importance of several of these factors (along with a few precautions about over-emphasizing them!) are discussed in the next section.

Research Related to the Concept of Class Inclusion.

Elkind's (1961) study is typical of those carried out to replicate Piaget's (1952) experiments designed to assess the ability of children to additively compose classes. One hundred children, aged five to eight years, were presented with the traditional "beads" test. Elkind reported three age related stages in the development of the children's ability to deal with class inclusions. The stages were identical to those of graphic collections, non-graphic collections and concrete operations described by Piaget.

Gates (1975) investigated children's understanding of the logical quantifiers "all" and "some." Tests patterned after Inhelder and Piaget (1964) were administered to children aged eight to eleven years. A linear relationship was found between age and performance. Scores for questions involving the use of "all" were higher than for questions involving the use of "some."

Wohlwill (1968) demonstrated that performance on class inclusion tests is influenced by perceptual factors. Class inclusion problems were presented to children aged five to seven years in the traditional manner using pictorial material (the child was shown pictures of four owls and two pigeons and asked, "Are there more birds or more owls?") and in a purely verbal manner (the child was asked, "If I had four owls and two pigeons, would I have more birds or more owls?").

The purely verbal presentation of the problem was significantly easier for the children. Further investigations led Wohlwill (1968) to attribute the superior performance on the purely verbal condition

to a "verbal facilitation effect" which tended to weaken "the subclass comparison set engendered by the perception of majority and minority subclasses in the pictorial conditions" (p. 462). These findings are not consistent with Piaget's (1967) suggestion that children find class inclusion problems easier when concrete objects are present not, when concrete objects are absent.

Other investigators (Tartarsky, 1974; Ahr and Youniss, 1970; Winer and Kronberg, 1974) have also reported that modification of the form of the traditional class inclusion tasks in ways that reduce contradictory perceptual cues, facilitates performance. Ahr and Youniss (1970) suggest that "at some points in the child's development an operation may be available but expressly retarded dependant upon variables effective in the concrete situation" (p. 142).

We are reminded at this point of the competence-performance aspect of development advocated by Flavell and Wohlwill (1969). Knowledge which is present in competence may not be manifested in the child's performance due to factors such as: (1) complexity and familiarity of task materials; (2) the amount of relevant and irrelevant information present in the test situation; and (3) memory and attention. These factors, as Jamison (1977) suggests, are not always easy to control in Piagetian testing.

Experimenters should exercise caution, however, with respect to oversimplification of test situations to elicit knowledge of concepts. It is easy to be trapped into situations in which easy tests produce clever children. Piagetians suggest "performance

can easily induce an overrating of competence" (Sinclair-De-Swart, 1969, p. 335).

The Development of Classification in Learning Disabled Children

The writer has been able to locate very little information in the literature regarding the development in learning disabled children of classification skills as described by Piaget. Klees and Lebrun (1972) compared groups of normal readers and dyslexics with respect to performance on Piagetian class inclusion tests. The severity of the reading problem of the dyslexics constituted a major learning disability for these children. The investigators found that the dyslexic children were very inferior to the normals in acquiring the notion of inclusion of classes.

Kirkbride (1977) studied the development of Piagetian logico-mathematical concepts (conservation, classification, seriation) and spatial concepts in achieving and learning disabled children. A total of 117 children were involved in the project. Twenty of the children served as normal controls and 97 of the children were learning disabled. A control group and five dysfunction groups, i.e., (1) reading disability, (2) arithmetic disability, (3) behavior disability, (4) reading and arithmetic disability, and (5) reading, arithmetic and behavior disability, were identified at two age levels, one younger than nine years six months and one older than nine years six months.

Performance on three Piagetian classficiation tasks (Additive Composition of Classes, Multiplicative Classification and the Duality Principle) was measured. The concepts of additive

composition of classes and multiplicative classification appeared to develop more slowly in the learning disabled children than in the achieving children. The majority of learning disabled children, however, did demonstrate operational performance on these two tasks.

The learning disabled children experienced great difficulty with the Duality Principle task. Of the 97 learning disabled children tested, only four reached the stage of concrete operations. Within this group of 97 children, 52 were above the age of nine years six months, and would be expected, i.e., by comparison with the chronological age range reported in the literature, to be at the stage of concrete operations. Only three of these children were, in fact, concrete operational. All of the oldest control children were either at the stage of concrete operations (10 percent) or formal operations (90 percent). The learning disabled children involved in this study lagged behind their normal peers with respect to the acquisition of concepts necessary to deal with (1) the quantification of the inclusion relations of the three level class hierarchy, (2) the notion of the "not" class, and (3) the symmetrical relationship between classes and their complementary classes.

According to Inhelder and Piaget (1964), the development of classification is essential to the development of logical and abstract thinking in the child. Consequently, classification skills may make an important contribution to the development of complex mental activities of the child such as the ability to read (Elkind, 1967, 1969; Housch, 1972; Furth and Wachs, 1975) and to perform

arithmetic operations (Hood, 1962; Piaget, 1972; Furth and Wachs, 1975) Several studies have indicated that Piagetian classification tasks are good predictors of achievement in reading (DeVries, 1974; Heatherly, 1972; Simpson, 1972; Smith, 1971, Kaufman and Kaufman, 1972). Correlation studies by Freyberg (1966) and Kaufman and Kaufman (1972) have found that Piagetian classification tasks are also good predictors of achievement in arithmetic. Disturbances in the development of classification skills of children may be reflected in their reading and arithmetic performance.

Factors Which May Influence the Development of Classification in Learning Disabled Children

Some insight into the problems experienced by learning disabled children with respect to classification tasks may be gained from consideration of: (1) some aspects of Inhelder and Piaget's (1964) theory of the development of classification in normal children; and (2) some aspects of the established literature regarding the etiology of learning disabilities. According to Inhelder and Piaget, the notions of classes and complementary classes are not preformed concepts present in the child at birth. The child's knowledge of classification grows out of acting upon objects in the environment, putting objects together to form classes and then taking those classes apart. Mental operations result from the internalization of these physical actions of the child. The mental operations are then organized to form the classification structure.

Inhelder and Piaget postulate that the actions of the child are the crucial factors which determine the development of

classification. Other factors, however, such as maturation, perception and language may be "necessary but not sufficient" for the completion of the classification structure. In normal children it is assumed that maturational processes, perceptual abilities, and language are unfolding as they should. Learning disabled children, on the other hand, are often characterized as exhibiting perceptual and linguistic problems and as lagging behind their chronological age peers (of the same measured intellectual potential) developmentally. The possible impact of deviation in maturation, perception and language upon the development of classification in learning disabled children will be discussed for each factor separately.

Maturation

Piaget (1977) suggests that maturation of the central nervous system plays a fundamental role in cognitive development by creating conditions which open up possibilities for intellectual growth. The actualization of these possibilities "demands not only the action of the physical environment (practice and acquired experience), but also the educational influence of a favourable social environment," (Inhelder and Piaget, 1964, p. 5). From the Piagetian position, it could be hypothesized that deviant maturation of the central nervous system could delay intellectual growth by failing to provide the conditions under which such growth becomes possible.

There is a wealth of literature which raises the question of impaired neurological functioning in learning disabled children (Meier, 1976; Cruickshank and Hallahan, 1975). Neurological damage

in these children is not usually attributed to actual organic lesions in the brain and central nervous system, but rather it is discussed in terms of minimal brain dysfunction. The syndrome known as minimal brain dysfunction is probably the most hotly debated issue with respect to the etiology of learning disabilities. Proponents of minimal brain dysfunction as a causative factor in learning disabilities focus on the so-called "soft signs" or behavioral manifestations of impaired neurological function, i.e., perceptual, integrative or temporal order sequencing problems, etc.

As yet, the evidence that learning disabled children do not learn because of malfunctioning central nervous systems is far from conclusive. Nonetheless, the research in this area cannot be ignored (Knights and Bakker, 1976). The disciplines of neurophysiology and neuropsychology are rapidly developing. In time, it is possible, that definitive evidence of maturational and biochemical factors related to the central nervous system which can affect the learning processes of learning disabled children will emerge.

Perception

Piaget suggests that cognitive functioning has two aspects, figurative and operative, both of which involve actions. The actions involved in the operative aspects of cognitive functioning result in actual "changes or transformations of reality," (Ginsburg and Opper, 1969, pp. 152-153). According to Piaget, for the child to know an object, he must act upon, construct, transform and reconstruct the object. These activities on the part of the child lead to the production of operational schemata which enable the child to comprehend

information.

The actions involved in the figurative aspect of cognition enable the child to obtain a "copy of reality," (Ginsburg and Opper, 1969). Under the rubric of figurative cognition, Piaget includes perception, imitation and mental imagery. Perception functions through the senses and enables the child to obtain a copy of objects in the immediate environment. Imitation is the process which allows the child to reproduce the actions of persons and things in the immediate environment. Mental imagery refers to the internal representation of absent objects or events.

According to Inhelder and Piaget (1964), perception is linked with "action schemata of a higher order," i.e., operative schemata, which influence perception at every level. Since Inhelder and Piaget have described normal development, it is assumed by the writer that the perceptual development to which they refer is normal. In learning disabled children perceptual development may not always be normal. Cruickshank (1972) has stated that "learning disabilities are essentially and almost always the result of perceptual problems based on the neurological system" (p. 383).

The perceptual dificit hypothesis of learning disabilities, particularly as it relates to reading disabilities, has been recently challenged in the literature by Vellutino, Steger, Moyer, Harding and Niles (1977). These authors regard verbal deficits as the major cause of reading disabilities. A large and respected body of research, however, suggests that many learning disabled children do exhibit perceptual deficits.

The contribution of sensori-motor deficits to children's learning disabilities has been reported in the research of Barsch (1965), Getman (1962), and Kephart (1960). Frostig (1967) and Frostig and Maslow (1973) have dealt extensively with visual-motor disturbances in learning disabled children. Intersensory integration problems of learning disabled children were initially discussed by Birch (1962) and Birch and Belmont (1964) and more recently Koppitz (1977) has reported the major significance of intersensory integration problems in learning disabled children requiring long-term special education. Deficiencies in the temporal ordering and sequencing abilities of learning disabled children have been studied by Bakker (1970), Johnson and Myklebust (1967), and Kirk and Kirk (1971).

Inhelder and Piaget (1964) suggest that at the very early stages of classification children perceive similarities and differences among the objects to be classified. Due to perceptual deficits, which they may experience, the ability of some learning disabled children to perceive similarities and differences may be impaired, and consequently their progress with respect to the development of classification delayed.

Language

Inhelder and Piaget (1964) suggest that the development of the operational structure of classification is closely associated with the development of language. The Piagetian view, however, with respect to the relationship between the development of logical thought and language is clear ... "language is not the source of

logic, but is on the contrary structured by logic," (Sinclair-de-Zwart, 1969, p. 395). According to Inhelder and Piaget (1964), language may "accelerate the formation of classes" by helping the child to center attention upon the important details of the classification tasks. This is particularly true when the child must cope with multiplicative or complex classifications, such as those involved in the Singular Class and Duality Principle tasks, which require a shift from one classification criterion to another when dealing with the same objects.

The Singular Class task requires the child to classify geometric shapes on the basis of three different criteria, i.e., shape, size and color. Language may help the child to shift from one classification criterion to another, and enable the child to overcome the distraction of perceptual cues when the 15 blue objects and the single red object are to be classified on the basis of color, in order to construct the Singular Class.

The importance of linguistic analysis of class inclusion tasks has been recognized in the literature (Shipley, 1979). Well developed language skills and verbal mediation (Hagen and Stanovich, 1977) would appear to be very important in dealing with the inclusion relations of the class hierarchy involved in the Duality Principle task. At the concrete operational stage of this task consistently correct labeling of the three subclasses, ducks, birds and other animals and the supra-ordinate class animals is essential. At the formal operational stage of the Duality Principle, the child must deal with abstract classes, i.e., not-ducks, not-birds, and

not-animals and the complex relationship animals > birds = not-birds > not-animals. The writer suggests that the child must have well developed language skills to reach the concrete and formal operational stages of the Duality Principle.

Hallahan and Kauffman (1976) suggest that as a group learning disabled children have more language problems than normal children. Recent publications (Vellutino, 1977; Vellutino, Steger, Moyer, Harding and Niles, 1977) have emphasized (perhaps over-emphasized!) the importance of language problems in reading disabilities. Vellutino and his colleagues suggest that, in contrast to perceptual deficit hypotheses of reading disabilities proposed by Birch (1962), Orton (1925, 1937) and Johnson and Myklebust (1967) among others, a verbal deficit hypothesis offers the most convincing explanation of dyslexia.

Reading disabilities appear to be very complex disorders and probably both perceptual and linguistic factors contribute to them. The present writer agrees with Fletcher and Satz (1979, p. 73) who suggest that ... "the current state of research in this area (reading disabilities) is such that no unitary deficit hypothesis can truly be accepted or rejected as completely explanatory." Some of the research cited by Vellutino (1977) in support of a verbal deficit hypothesis of reading disability is presented here, however, as illustrative of the types of language problems which some learning disabled children may experience.

Vellutino (1977) suggests that both indirect and direct evidence is available in the literature to support his verbal

deficit hypothesis of reading disability. As indirect evidence, Vellutino cites studies by: (1) Rabinovich (1959, 1968) who found that, generally, poor readers did not perform as well as good readers on verbal measures of intelligence; and (2) Huelsman (1970) and Belmont and Birch (1966) who reported that the performance of disabled readers was often inferior to that of good readers on the verbal subscales but not on the performance subscales of the Wechsler Intelligence Scale for Children.

Vellutino has also proposed that research by himself and his associates provides indirect support for a verbal deficit hypothesis of reading disability (Vellutino, Steger and Kandel, 1972; Vellutino, Smith, Steger and Kaman, 1975). Vellutino and his colleagues have compared the performance of good and poor readers on a variety of visual recognition tasks. The tasks are described as: visual-visual, i.e., copying geometric designs; visual-verbal, i.e., copying and naming scrambled letters and words; and verbal-verbal, i.e., pronouncing words. The only tasks upon which the reading groups differed were the verbal-verbal tasks. The authors concluded that these results contradicted a perceptual deficit and supported a verbal deficit hypothesis of reading disability. The results and conclusions of Vellutino and his colleagues have been challenged by Fletcher and Satz (1979) who have questioned the construct validity of the tasks employed and test ceiling effects.

As direct evidence to support the hypothesis of a verbal deficit as the major cause of reading disability, Vellutino (1977) has referred to a number of studies which relate reading problems

to disturbances in the semantic, syntactic and phonologic aspects of language. According to Vellutino, the close association between semantic factors and reading disability is demonstrated by research which suggests that poor readers experience difficulty with "rapid automatic naming" tasks, and exhibit deficiencies with respect to the storage and retrieval of information in short term memory. Among studies cited by Vellutino in this regard are those of Denckla and Rudel (1976) and Perfetti and Goldman (1976).

Denckla and Rudel (1976) employed "rapid automatic naming" tasks to compare the performance of normal and poor readers (aged seven to 12 years). The poor readers were less accurate and required more time to generate labels for objects, colors, letters, numerals and words which were presented visually.

The performance of poor and good readers (in both the third and fifth grades) on measures of semantic encoding and verbal memory was compared by Perfetti and Goldman (1976). These investigators concluded that poor readers did not make use of a linguistic code, i.e., implicit labeling, to process information in short-term memory as efficiently as good readers.

Vellutino (1977) suggests that syntactic development is deficient in poor readers. The work of Fry (1967) and Schulte (1967) is cited. These researchers reported that poor readers in the second grade were characterized by deficiences in "verbal fluency, speaking vocabulary, organizational and integrative skills, abstract usages, grammar, and complexity of sentence structure" (Vellutino, 1977, p. 344).

Vogel (1974) also reported deficiencies in the syntactic abilities of dyslexic children. In a subsequent investigation (Vogel, 1975), she found significant correlations between receptive vocabulary and reading comprehension in normal readers but not in dyslexics. Vogel suggested that the reading disabled child "because of his syntactic deficiencies is unable to comprehend the relational aspects of words and therefore is blocked from fully utilizing the semantic information he possesses" (Vogel (1975) cited in Cummins and Das, 1977, p. 353).

Phonologic deficiencies have been observed in reading disabled children and have been associated with their inability to discriminate speech sounds (Wepman, 1960, 1961). Blank (1968) and Shankweiler and Liberman (1972) have proposed that, in the absence of real deficiencies in auditory acuity, reading disabled children can hear the acoustic differences between minimally contrasted words as well as other children. Vellutino (1977) suggests:

> ... poor readers may have less ability than average readers to explicate phonemic differences in similar sounding words that they implicitly discriminate ... poor readers may be more sensitive to the acoustic (sounds of words as wholes) than to the phonemic (sounds of parts of words) properties of such words ... (consequently) poor readers would be able to perceive words as syllabic or articulatory units but have little or no awareness of the word's phonetic structure ... The severity of some children's reading problems may be related to their conscious awareness of the phonetic structure of speech.
>
> (Vellutino, 1977, p. 346).

Summary and Conclusions

The discussion of Piaget's theory of the development of the operational structure of classification and the review of the research presented here indicated:

1. Logical thinking in the child depends, in part, upon the development of a classification system.
2. Classification originates in the sensori-motor activities of the child. The development of classification involves the ability of the child to construct a class hierarchy and to understand the inclusion relations which exist between levels of the hierarchy. Mastery of class inclusion requires an understanding of the permanent inclusion of the parts in the whole, and the use of the logical quantifiers, "all" and "some." Piaget describes four developmental stages in the child's construction of a class system. Two pre-operational stages are followed by a concrete operational and in some cases a formal operational stage of genuine classification.
3. As the child actively constructs his own classification system, he deals with the notion of complementary classes. Particular instances of complementary classes which are relevant to this investigation and which were described above are: (a) negation of classes and the singular class, concepts which develop during the concrete operational period; (b) the null class, a concept which

develops at the borderline between concrete operational and formal operational thought; and (c) the Duality Principle which includes a concept which extends into the formal operational period.

4. The research has indicated support for the sequential development of pre-operational and operational stages of behavior described by Piaget for the various classification tasks, i.e., Additive Composition of Classes, etc. The research is somewhat controversial with respect to the sequence of mastery of the various classification concepts, and the order in which they emerge in the performance of the child.
5. Research has demonstrated that in some cases performance on class inclusion tasks is influenced by perceptual and linguistic factors.
6. Classification concepts may be essential for academic achievement in reading and arithmetic.
7. According to Piaget, maturation, perception and especially language may be factors which are necessary, but not sufficient, for the completion of the operational structure of classification.
8. The literature indicates that the population of learning disabled children is very heterogeneous. The children demonstrate maturational lags, perceptual and verbal deficits.

9. There is some evidence to support the theory that learning disabled children lag behind their normal peers with respect to the development of classification skills.

In conclusion, learning disabled children constitute a very heterogeneous population. These children have been characterized in the literature as demonstrating maturational lags, perceptual deficits and language problems. There is certainly no consensus as to a single cause of learning disability.

The development of classification skills is, according to Piaget, essential to the development of logical thinking in young children. Again and again, Piaget has stressed that it is the actions performed by the child on the objects in his environment that are crucial to the development of classification concepts. Piaget does emphasize, however, that maturation, perceptual factors and language make important contributions to the development of classification in the child. Classification appears to be a type of mental activity which is vulnerable to many factors with respect to its proper development. Slow and/or poor development of classification skills may be a general characteristic of learning disabled children and not confined to children with a specific type of learning disability.

The study of the development of classification skills in learning disabled children would seem to be a worthwhile endeavour. Do the classification skills of learning disabled children develop in the same way as the classification skills of normal

children, but at a slower rate? If learning disabled children lack classification skills, is this lack reflected in deficits in other cognitive abilities such as memory? The present investigation sought some answers to these questions.

CHAPTER III

REVIEW OF RELEVANT MEMORY THEORIES AND RESEARCH

The literature of human memory research is enormous and continues to increase. The review presented here includes only research pertinent to the present study and will consider: (1) definitions of memory; (2) information processing models of memory; (3) developmental aspects of memory; (4) the use of levels of processing models to study memory development in children; (5) investigations of memory abilities in learning disabled children; and (6) factors which may influence the development of mnemonic strategies in learning disabled children.

Definitions of Memory

What is memory? For decades scholars have attempted to provide precise definitions of the phenomenon known as memory. Research has led to the analysis and definition of a number of aspects of memory, but no one all inclusive definition that adequately describes memory has emerged. Many investigators in defining memory postulate an intrinsic bond between memory and knowledge.

Piaget (1964) has suggested that ... "Memory seems to be a special case of intelligent activity, applied to the reconstruction of the past" (p. 16). Piaget and Inhelder (1973) defined "memory in the strict sense" as memory for specific events, meaningful and non-meaningful, which the rememberer feels were personally experienced by him; and "memory in the wider sense" as the retention by the rememberer of the meaningful products of his cognitive

activities. The cognitive "schemas" acquired by the subject are "conserved" in memory.

Tulving (1972) also distinguished two types of memory, episodic memory and semantic memory. Episodic memory, according to Tulving, is concerned with the reception and storage of "information about temporally dated episodes or events, and temporal-spatial relations among these events." Semantic memory, on the other hand, is the organized body of knowledge which a person possesses" about words and other verbal symbols, their meaning and referents, about relations among them, and about rules, formulas, and algorithms for the manipulation of these symbols, concepts and relations" (pp. 385-386).

Meachum (1972), after a comprehensive review of recent American and Soviet theory and research regarding memory, concluded that memory can be ... "conceptualized as an epiphenomenon of various cognitive activities such as classifying, rehearsing, labeling, visual imagery, and sentence elaboration" (p. 205). Much of the research tends to endorse the viewpoint that memory cannot be dealt with as a single entity and cannot be separated from other mental processes. Memory should be studied in relation to the myriad cognitive operations that appear to contribute to the functioning of memory in human beings.

Information Processing Models of Memory.

The introduction of information processing models of memory (Broadbent, 1958; Atkinson and Shriffrin, 1968) has led to remarkable progress in our understanding of the psychology of human

memory. These models emphasize, in varying degrees, two aspects of information processing, either structure or process.

Structural Models.

Information processing models of memory which are oriented towards structure (Murdock, 1967, 1972) tend to describe the flow of information through a compartmentalized system of memory stores, i.e., sensory stores, short-term store and long-term store. Specific characteristics of the different stores determine the amount of information processed as well as the manner in which information is processed. Distinctions between the stores tend to be most frequently based on features such as entry, maintenance and format of information, store capacity, rate of information loss, the durability of the memory trace and method of information retrieval.

Levels of Processing Models.

Information processing models of memory which emphasize process are chiefly concerned with the processes or strategies involved in the encoding, storage and retrieval of information. The process model of memory which was of primary interest in this investigation was the levels of processing model of Craik and Lockhart (1972).

Craik and Lockhart questioned the adequacy of a multistore theory of memory and proposed a levels of processing approach as an alternative framework for memory research. According to Craik and Lockhart, the analysis of incoming perceptual stimuli or information proceeds through a hierarchy or "series of sensory stages

to levels associated with matching or pattern recognition and finally associative stages of stimulus enrichment" (p. 675). The "depth of processing" is related to the degree of "semantic or cognitive analysis" to which information is subjected. The persistence of the memory trace "is a function of the depth of analysis, with deeper levels of analysis associated with more elaborate, longer lasting, and stronger traces" (p. 675).

Since its introduction in 1972 the levels of processing model has been modified by Craik and Lockhart and their colleagues. Originally, perceptual analysis was viewed as a continuum with incoming stimuli proceeding through a fixed series of analysers ranging from structural to semantic. Processing stopped when the analysis pertinent to the task was achieved. Craik and Tulving (1975) suggest that the series of analysers postulated by Craik and Lockhart (1972) could not lie on a continuum since structural analyses of stimuli do not necessarily shade into semantic analyses of the stimuli.

Lockhart, Craik and Jacoby (1976) proposed that the "physical, phonemic and semantic characteristics of words" reside in a hierarchical organization of discontinuous "qualitatively coherent" encoding domains (Sutherland, 1972). The hierarchy of domains proceeds from "shallow" structural domains to "deeper" semantic domains. Processing proceeds from one domain to another. Memory traces which are by-products of processing in deeper semantic domains are more persistent than those produced by processing in shallower domains. As in the 1972 levels of processing model,

Lockhart, Craik and Jacoby (1976) retain the notion of "depth" as a qualitative measure of the type of processing to which stimuli are subjected. "Greater" depth continues to be associated with "deeper" processing.

Processing may also occur within a domain, according to Lockhart, Craik and Jacoby (1976), and is referred to as "elaboration" or "spread" of encoding. The degree of elaboration depends upon the amount of processing of the same general type that is required to extract meaning from a stimulus. Elaboration enhances the accessibility and memorability of an event.

Craik and Lockhart (1972) proposed that meaningful stimuli are processed to a deeper level and are better retained than less meaningful stimuli. This is due to the "compatibility" between the familiar stimuli and "existing cognitive structures." It was also noted that,"the effectiveness of a retrieval cue depends on its compatibility with the item's initial encoding or, more generally, the extent to which the retrieval situation reinstates the learning content" (p. 678). Craik and Lockhart did not, however, give major consideration to retrieval of information from memory.

The original and modified versions of the Craik and Lockhart (1972) levels of processing model have been challenged in the literature. Both Eysenck (1977, 1978) and Baddeley (1978) have criticized the failure of Craik and Lockhart to incorporate an independent measure of processing depth and elaboration into their model.

Typical investigations of levels of processing involve the

presentation of a series of orienting questions and stimulus words. The orienting questions induce the subject to process the words to one of several levels of processing, i.e., physical, phonemic, and semantic. Eysenck (1977) points out that classification of word features and attributes as physical, phonemic and semantic is ad hoc. This arrangement does not provide a satisfactory index of either depth of encoding or elaboration. "There is danger of using the retention-test performance to provide information about the depth of processing, and then using the alleged depth of processing to 'explain' the retention-test performance, thus producing a vicious circle" (p. 30).

Eysenck and Baddeley both point to lack of attention to output processes as a major inadequacy of the levels of processing theory. Craik and Lockhart (1972) emphasize input operations such as the type of instructions given to the subject and the nature of the stimulus when they describe the memory trace. Eysenck (1978) suggests ... "the greatest understanding of an intervening variable such as the memory trace is likely to emerge from a simultaneous consideration of input and output operations" (p. 162).

Lockhart and Craik (1978) have taken the comments of their critics under advisement. They admit, for example, that the lack of an independent measure of depth does limit the levels of processing approach, and that there is a definite problem of circularity in the descriptive logic. Lockhart and Craik, however, argue that their 1972 levels of processing model was introduced as an alternative framework for memory research and stress the "heuristic value

of their original statement." The model has indeed generated research, been modified as a result of the findings, and continues to appeal to students of memory.

Developmental Aspects of Memory.

What, in fact, memory development is really the development of has emerged as a very debatable issue in psychology. Piaget (1968) has proposed that the activities of the memory are inseparable from the structural activities of the intelligence. "The schemata used by the memory are borrowed from the intelligence, and this explains why they follow one another in stages corresponding to the subject's operational level" (Piaget and Inhelder, 1973, p. 382). Further to this, Piaget and Inhelder suggest that the memory trace itself may actually change over time:

> The memory is a store of information that has been encoded by way of a process of perceptive and conceptual assimilation. The information itself, however, depends in part on the code ... Memory changes in the course of a subject's development do not simply reflect the level of his encoding and decoding powers (i.e., strategies): the code itself is susceptible to change during the construction of operational schemata. This explains why the level of memory organization differs with age, reflecting not only the coding level of the subject, but also the transformation of the code in the course of retaining the memory.
>
> (Piaget and Inhelder, 1973, cited by Brown, 1975, p. 114).

Piaget (1968) describes a developmental course for memory which progresses from recognition to reconstruction to evocation, i.e., recall. Recognition memory is a primitive process which derives from sensori-motor activity. Recognition memory requires that the object be present and "consists of perceiving the latter as something known." Reconstructive memory is an early form of recall that

involves recall by "actions instead of images." Reconstruction restores "the supposed genetic order of the formation of memories (actions ⟶ schemata ⟶ memory images), simple recall reverses the order by starting from the images" (Piaget and Inhelder, 1973, p. 391).

Piaget (1968) emphasizes the developmental importance of reconstructive memory. Imitation, according to Piaget, is a form of reconstructive memory. The imitation of a model is involved. Evocation memory or recall requires some form of mental imagery or language. Some form of symbolic function or some form of operational or pre-operational representation is essential for the development of evocation memory. Piaget concludes that memory has two components, one figurative, the other operative. The figurative component is perceptual in the case of recognition, imitative in the case of reconstruction and involves mental imagery in the case of evocation or recall. The operative component consists of action "schemas" or representative "schemas." The "schemas" may be either pre-operational or concrete operational.

Flavell (1977) has related the development of memory to the development of four categories of phenomena, basic processes, knowledge, strategies and metamemory. These topics will be discussed separately.

<u>Basic processes</u> refer to the "hardware" of the memory system and include recognition and recall. Recognition memory has been detected in very young babies, recall seems to emerge during the late infancy period. Flavell has proposed that the development of these basic processes may be virtually completed by the end of the

sensori-motor stage of development.

The knowledge a person possesses determines to a great extent what will be stored in memory and retrieved from memory (Brown, 1975; Chi, 1977; Flavell, 1977). To advocates of the theory that memory may, in fact, be "applied cognition" (Flavell, 1971) the developmental implications of the dependence of memory on knowledge and understanding are clear:

> Older individuals will presumably store, retain and retrieve a great many inputs better or differently than younger ones, for example, simply because developmental advances in the content and structure of their semantic or conceptual systems render these inputs more familiar, meaningful, conceptually interrelated, subject to gap-filling, or otherwise more memorable to them.
>
> (Flavell and Wellman, 1977, p. 4).

Strategies are the "potentially conscious" acts that are available to and used by a person to facilitate remembering. Storage strategies which include rehearsal, organization and elaboration have been studied in some detail (Brown, 1975; Chi, 1976, 1977; Flavell, 1970; Moely, 1977; Hagen, Jongeward and Kail, 1975). Retrieval strategies such as memory search and decision making processes have not been studied extensively (Kobasigawa, 1977).

Flavell (1970, 1977) suggests that strategy formation proceeds through a series of developmental stages. At the initial stage, the young child cannot execute the strategy even when carefully instructed to do so. A "mediation deficiency" is said to exist. At the next stage, the child can and will execute the strategy when instructed to do so and memory benefits accrue from its use. The

child will not, however, execute the strategy spontaneously at this stage. This behavior pattern with respect to strategy use is called "production deficiency." At the final stage of strategy development, the child will execute the strategy spontaneously on his own initiative.

The formation of the mnemonic strategy known as category organization appears to follow a developmental course similar to that described by Flavell. Organization has long been recognized as a factor of central importance with respect to memory performance. Bousfield (1953) reported the tendency of subjects to cluster words presented in a random fashion into conceptual categories for purposes of recall. Age related trends in the use of category organization for recall have been reported by Niemark, Slotnick and Ulrich (1971); and Moely, Olsen, Halwes and Flavell (1967), among others.

Moely (1977) suggests that children between the ages of five and nine tend to exhibit, in varying degrees, production deficiencies with respect to the use of category organization for recall. Children between the ages of 10 and 11 frequently use category organization as a means of dealing with recall tasks. Moely attributes the superior performance of the older children to their increased knowledge of semantic categories.

The study of the importance of various types of strategic behavior in relation to increased memory efficiency appears to be one of the most promising areas of developmental memory research.

Metamemory refers to knowledge about the memory. Flavell

(1977) suggests that young children seem to develop a sensitivity for situations that require an effort to store and retrieve information. As children grow older, they develop the ability to assess their own memory capabilities in a realistic and accurate way (Kreutzer, Leonard and Flavell, 1975). When children begin to monitor their memory experiences, they become aware of what makes some memory tasks simple and others difficult. In addition as children grow older they seem to realize which types of strategies are most appropriate for different types of memory tasks.

<u>The Use of Levels of Processing Models for the Study of the Development of Memory in Children</u>.

Researchers have begun to use the Craik and Lockhart (1972) levels of processing model to study the development of memory in children (Kirkbride, 1978a; Lupart, 1978; Snart, 1979; Geis and Hall, 1976; Owings and Baumeister, 1979). As mentioned in the introductory chapter of this thesis, features of the levels of processing approach to memory which make it attractive to developmentalists are: (1) the concern with the mental operations or activities carried out by the subject at the time of stimulus encoding and to a lesser extent at the time of information retrieval; and (2) the notion that memory involves the assimiliation of incoming information to the subject's existing knowledge base (Brown, 1979; Reese, 1973, 1976).

Naus, Ornstein and Hoving (1978) considered the developmental implications of multistore and depth of processing memory models. They concluded that both models were equally useful for the study

of deliberate or voluntary memory. The levels of processing model was considered to be superior, however, for the study of involuntary or automatic memory processes. The superiority of the levels of processing model in this regard was attributed to the emphasis the model places upon the interpretation of incoming information in terms of the subject's current knowledge base.

The most comprehensive study of the development of memory in normal children using the levels of processing approach is perhaps that of Snart (1979). A levels of processing task was administered to 50 children at each of three age levels, i.e., six years, 11 years, and 16 years. Significant differences for total recall were found between the six and 11 year old children and between the six and 16 year old children. At all age levels, recall of words processed at the semantic level was superior to recall of words processed at either the phonemic or physical levels. The hierarchy of recall for words processed at physical, phonemic and semantic levels proposed by Craik and Lockhart (1972), i.e., semantic > phonemic > physical was substantiated by Snart's study.

Geis and Hall (1976) presented a levels of processing task to children in grades one, three and five. Processing of the orthographic, acoustic and semantic characteristics of the words was involved. Depth of encoding was significantly related to recall and the study provided direct support for the levels of processing theory. Geis and Hall, however, did not obtain a significant main effect for age which is the usual finding with increasing age levels.

Following the administration of levels of processing tasks to students in grades two, four and six, and in junior and senior high school, Owings and Baumeister (1979) reported significant age trends in recall. Semantic encodings were more often recalled than either phonemic or physical encodings (which did not differ significantly).

Kirkbride (1978a) compared the performance of achieving and learning disabled children on a levels of processing task. Ten achieving and ten learning disabled children at each of three age levels, eight to nine years, 10 to 11 years and 12 to 13 years were tested. Results of the study indicated that: (1) total recall of the achieving children was significantly superior to that of the learning disabled children; (2) for both achieving and learning disabled children significant differences for total recall were found between the youngest and the middle groups of children and between the youngest and oldest groups of children; and (3) both the achieving and learning disabled children recalled most words at the semantic level. The children did not, however, recall more phonemic than physical level words.

The studies using the levels of processing model (Craik and Lockhart, 1972) to investigate memory development in children have usually found age related trends in free recall performance. Older children recall more information than younger children. Generally, children at all age levels recall more words processed at the semantic level than at either the physical or phonemic levels. This finding does not support previous investigations which

suggest, that in tests of free recall, young children tend to recall the phonemic attributes of words, while children aged eight years and older tend to recall semantic attributes (Naron, 1978; Hasher and Clifton, 1974).

Investigations of Memory Abilities in Learning Disabled Children

Torgesen (1975) suggests that the most reliable finding, with respect to the memory performance of learning disabled children, is that these children tend to do more poorly on memory tasks than normal children. The reasons for this poor performance, however, are not clear. The inferior memory ability of learning disabled children has been attributed to factors such as limited memory capacity, and the inefficient use of mnemonic strategies.

Hallahan (1975) reviewed a number of investigations which assessed the short-term auditory and visual memory capacity of learning disabled children by measuring the overt end products of memory. The majority of studies reviewed by Hallahan were not well documented with respect to details of the sample populations and the results of the investigations were conflicting. For example, Dornbush and Basow (1970) studied visual and auditory memory in good and poor readers and reported no significant differences while Bryan (1970) found that learning disabled and normal children did differ with respect to visual and auditory memory performance. Alwitt (1963) investigated visual memory processes in disabled and normal readers and found no differences. On the other hand, Stanley and Hall (1973) found the visual memory of dyslexic children inferior to that of normal children. Differences in

performance by disabled and normal readers on paired associate learning tasks were reported by Goyen and Lyle (1971) but not by Craik and Goodsell (1968).

Investigations dealing with the ability of learning disabled children (primarily children with reading problems) to use control processes, i.e., mnemonic strategies, were recently reviewed by Torgesen (1978, 1980) and Torgesen and Kail, Jr. (1980). These authors concluded that the results of the investigations were quite consistent, and indicated that many learning disabled children do not use various mnemonic strategies (verbal labeling, rehearsal and categorization) as efficiently as their normal peers. The following studies are representative of those discussed by Torgesen (1978, 1980) and Torgesen and Kail, Jr. (1980).

Tarver, Hallahan and Kauffman (1976) studied the development of verbal labeling and rehearsal strategies in reading disabled boys at three age levels (eight, 10 and 13 years). Control groups matched with the reading disabled subjects for age and IQ were included in the study. The test material consisted of a horizontal array of pictures, presented one at a time, and then turned face down. Subjects were asked to locate the position of a probe picture in the horizontal array. Results indicated that both total recall and primary recall increased with age. At the youngest age level, however, only normal subjects demonstrated a primacy effect. Tarver, Hallahan and Kauffman concluded that: (1) reading disabled children were not as efficient as normals with respect to the use of verbal labeling and rehearsal; and (2) compared to normals,

reading disabled children follow the same developmental progression with respect to the use of rehearsal, but the rate of development of the strategy is slower.

Deficient use of verbal labeling and rehearsal strategies by reading disabled children has also been reported by Blank and Bridger (1966), Kastner and Rickards (1974) and Torgesen and Goldman (1977). The latter investigators found that instructions to rehearse eliminated the differences in recall between good and poor readers.

Torgesen and Houck (1980) studied the use of rehearsal strategies in sequential memory tasks by learning disabled children with auditory sequencing problems, learning disabled children with different types of processing problems, and normal children. The groups were matched for age and IQ. The tasks involved the presentation of digits at rates of four per second, two per second, one per second, and one per two seconds. The performance of the poor memory group was inferior to that of the other two groups. The groups by rates interaction was significant since the performance of both learning disabled groups declined as the presentation rate for the digits slowed from one per second to one per two seconds. Torgesen (1980) suggests ... "difficulties in the application of efficient task strategies may be a general characteristic of learning disabled children, even across groups that have different kinds of specific processing problems" (p. 366). Similar findings regarding inefficient use of rehearsal strategies by heterogeneous groups of learning disabled children have been

reported by Bauer (1977) and Cohen and Netley (1978).

Of particular importance to the present investigation are studies which have looked at the ability of learning disabled children to use more elaborative encoding strategies such a categorization. Parker, Freston and Drew (1975) compared the memory performance of normal and learning disabled children aged eight to 11 years as a function of input organization. Children in both groups were of average intelligence. The learning disabled children demonstrated 25 percent or more retardation with respect to grade placement and academic achievement. The children were presented with organized and un-organized lists of words. Performance on free recall tests indicated that learning disabled children could not take mnemonic advantage of externally organized material.

Torgesen (1977) presented poor and good readers in the fourth grade with 24 pictures representing four categories of objects. During a two-minute study period, the children were encouraged to move the pictures about or to engage in any other activity which they felt would assist them in remembering the objects. Not only did the good readers demonstrate recall performance that was superior to that of poor readers, but they also were more inclined to group the stimulus material into categories during the study period. Torgesen found that differences in recall between good and poor readers were eliminated when the children were given brief training in the use of category organization as a mnemonic strategy. Deficiencies in the ability of learning disabled children to use category

clustering as an aid for the recall of information have also been reported by Bauer (1979), Dellago and Moely (1979), Torgesen, Murphy and Ivey (1979), and Wong, Wong and Foth (1977).

Factors Which May Influence the Use of Mnemonic Strategies by Learning Disabled Children

With respect to the inefficient use of mnemonic strategies by learning disabled children, Torgesen (1980) has considered the possible contributions of verbal deficits and the slow development of various task strategies. Labeling, rehearsal and categorization are all strategies which involve verbal skills. Failure to use these strategies could be attributed to linguistic problems (Vellutino, 1977). Performance differences between normal and learning disabled children have been eliminated, however, when the latter have been given brief training in the use of mnemonic strategies (Torgesen, 1977; Torgesen and Goldman, 1977). Torgesen (1980) suggests that ... "If the initial differences between children of different learning skills were due solely to relatively stable differences in basic linguistic skills, it would seem that minimal training should not have such a powerful effect on reducing differences between groups" (p. 369).

Flavell (1977) suggests that the development of cognitive strategies proceeds through sequential stages. Mnemonic strategy development may occur more slowly in learning disabled children than in normal children (Tarver, Hallahan and Kauffman, 1976).

According to Torgesen (1980), learning disabled children may not use mnemonic strategies as effectively as normal peers because

the former have only recently acquired the basic skills necessary for the execution of the strategies. The learning disabled children may have had insufficient time to practise the skills in an organized way to assist learning. Torgesen suggests that the "developmental lag" hypothesis will require verification by "careful developmental studies that document a slower rate of development in learning disabled children for the basic skills required to execute the strategies" (Torgesen, 1980, p. 369). Such documentation of classification skills and their possible influence on memory performance was one of the major purposes of the present investigation.

Summary and Conclusions

The theory and research reviewed in this chapter has indicated:

1. Memory cannot be defined as a single entity and cannot be separated from other mental processes.
2. Memory is developmental in nature. Piaget (1968) suggests that memory and intelligence are inseparable. The operations (strategies) involved in memory processes are derived from cognitive structures, which develop in the child during the sensori-motor, pre-operational, concrete operational and formal operational periods of cognitive development. According to Flavell (1977) the development of memory can be explained in terms of the development of four categories of phenomena, i.e., basic processes, knowledge, strategies and metamemory.

3. It has been suggested (Reese, 1973, 1976) that the development of memory might be studied by merging a theory of development, such as Piaget's, with a levels of processing model of memory such as that proposed by Craik and Lockhart (1972). Features shared by these models which make them compatible for research purposes are: (a) concern with mental operations or activities carried out by the subject at the time of stimulus encoding and decoding; and (b) the notion that memory involves the assimilation of incoming information to the subject's existing knowledge base (Brown, 1979).
4. The results of investigations that have assessed the short-term auditory and visual memory capacity of learning disabled children by measuring overt end products of memory have been conflicting.
5. Researchers who have studied control operations, i.e., strategies, used by learning disabled children to recall information have reported fairly consistent results. Learning disabled children do not seem to employ mnemonic strategies as efficiently as their normal peers.
6. Research has indicated age related trends in the development of mnemonic strategies.
7. There is some evidence of slow development of mnemonic strategies in learning disabled children.
8. The slow development of mnemonic strategies in learning disabled children may be related to the slow development

of the basic cognitive skills required to execute the strategies (Flavell, 1977; Torgesen, 1980).

In conclusion, there is a very real and immediate need for information about the memory abilities of learning disabled children. The comprehensive study by Snart (1979) suggests that the levels of processing approach is appropriate for the study of memory development in normal children. The work of Kirkbride (1978a) suggests that the levels of processing approach is useful for comparing memory development in achieving and learning disabled children.

The levels of processing model provides a means for studying the processes or strategies used by achieving and learning disabled children to encode and retrieve information. The model might also provide a means for relating the use of a mnemonic strategy such as categorization (which appears to be involved in semantic processing) to the level of development of classification structures from which, according to Piaget, the mnemonic strategy is derived.

An investigation of the relationship between memory ability and the operative level of development of classification skills in achieving and learning disabled children based on the information presented above would involve: (1) the use of a levels of processing task to measure recall in situations where categorization would appear to function as an appropriate encoding strategy and retrieval cue; and (2) the assessment of the operative level of classification skills using a Piagetian test battery.

In the past, the relationship between memory ability and the operative level of development of cognitive concepts has not usually been studied in the way proposed here, but rather in the manner proposed by Piaget (1968). Children are presented with stimulus models such as seriated arrays, and their immediate and long-term memory for the models measured. Accuracy of memory for the model has then been compared to the operational level of development of seriation skills in children. Piaget's memory research and the work of others who have investigated the relationship between memory and cognitive development are discussed in Chapter IV.

CHAPTER IV

THE RELATIONSHIP BETWEEN OPERATIVITY AND MEMORY

An integral link between cognitive development and memory has been postulated by Piaget and his colleagues (Piaget, 1968; Piaget and Inhelder, 1973) and also by students of constructive memory (Paris and Lindauer, 1976). The research of the Piagetians and the constructivists developed independently but they share similar views with respect to both the nature and development of memory.

According to Piaget, the activities of the memory and the intelligence are inseparable, the child's memory abilities are integrally linked to the operational schemata he possesses (Piaget and Inhelder, 1973). The two major tenets of Piagetian memory theory are: (1) children at different stages of cognitive development will remember stimuli differently; and (2) the individual child's memories will change in accordance with changes in the operative level of cognitive development in the child. Piaget's memory theory is often referred to in the research as an operative memory theory.

Students of constructive memory agree with Piagetians that memory depends to a great extent upon knowledge and cognitive actions. Individuals tend to remember best, information that is organized and meaningful. In the constructivist's view, information is not simply "copied" into memory at the time of input nor "copied" out of the memory at the time of retrieval . . . "the act of comprehending and encoding into memory is a Piagetian assimilation-type process of construction of an internal conceptual

representation of the input ... (and) retrieval is conceptualized as an equally active and assimilatory process of reconstruction" (Flavell, 1977, p. 192). Research in the area of constructive memory has only recently begun (Paris and Lindauer, 1976, 1977).

Piaget's Memory Research.

Piaget and Inhelder (1973) used many different stimuli to study the relationship between memory and operativity, among them were seriated arrays, matrices, examples of class intersections, cause and effect as evidenced by levers and transmitted motion, and structures involving spatial configurations and transformations.

The most striking support for their memory theory was obtained by Piaget and Inhelder with experiments using seriated arrays. Children, aged three to eight years, were shown ten sticks of different lengths arranged in a correct serial order. The children were told to look at the arrangement very carefully so that they could reproduce it (draw it) at a later time. The children were asked to draw the array one week after its presentation and again after a period of eight months.

The different age groups remembered the stimulus differently. The children did not remember the perceptual model, but rather they remembered the way that they had assimilated the model to their individual operational schemata (Piaget, 1968). The drawings made by the children depended upon their understanding of seriation. Three to four year olds indicated no signs of the original ordering, they tended to draw lines of equal length or irregular

hatches; five year olds drew lines arranged in unmatched pairs, representing alternating short and long sticks or they drew triplets of three short sticks followed by three long sticks; six year olds drew small series of sticks, but never included ten sticks in the series; and seven and eight year olds drew the original array in a seriated order. The age difference in memory performance corresponded to the age difference noted when the children were administered a seriation task requiring the spontaneous construction of a seriated array.

The longitudinal data available from this experiment indicated that, after eight months, 74 percent of the children produced drawings depicting more highly seriated arrays compared to their one week drawings, and in 26 percent of the children memory remained stable. No regressions in memory occurred.

Piaget contends that during the eight months period, the experience of comparing objects of different sizes resulted in the development of schemata of higher level seriation in many of the children. These new schemata subsequently served as the code for decoding the memory. The final memory is a decoding but ... "It is a decoding of a code which has changed, which is better structured than it was before and which gives rise to a new image which symbolizes the current state of the operational schema and not what it was when the encoding was done" (Piaget, 1968, p. 12).

Replications of Piaget's Memory Research.

The memory research of Piaget (1968) and Piaget and Inhelder (1973) has prompted a number of replication studies. Many of the

studies have focused on immediate and long-term memory for seriated arrays (Dahlem, 1969; Finkel and Crowley, 1973; Altmeyer, Fulton and Berney, 1969) but several have looked at memory for the concepts of horizontality, verticality and spatial transformation (Liben, 1974; Furth, Ross and Youniss, 1974). Liben (1976) has provided an excellent, comprehensive review of the major findings of a number of these investigations. Details of the research will not be presented here but rather a summary of Liben's conclusions about them.

According to Liben, the literature lends general support to Piaget and Inhelder's operative theory of memory. The most solid support for the theory is derived from cross-sectional research involving groups of children at various age levels. Children of different ages do seem to remember stimuli, in a manner which runs parallel to the development of related cognitive operations described by Piaget. Results of longitudinal research which has investigated memory improvement in individual children are less conclusive. Some children do exhibit long-term memory improvement as measured by the accuracy of reproduction of test stimuli. The incidence of long-term memory improvement is not nearly so great as that reported by Piaget and Inhelder (1973).

One replication of the Genevan memory research has particular relevance for the present investigation. Trepanier (1978) compared the performance of normal and learning disabled children aged seven to 10 years on Piagetian memory tasks. Normal and learning disabled children were matched for age, sex and IQ. All of the

children demonstrated concrete operational thinking as assessed by the Goldschmidt and Bentler Concept Assessment Kit-Conservation. The performance of the learning disabled children on the visual sequential memory subtest of the Illinois Test of Psycholinguistic Abilities was inferior to that of normal children.

Trepanier presented her subjects with two stick arrays, an "arbitrary" array consisting of sticks of the same length but of different colors, and a typical Piagetian seriated array consisting of sticks arranged in order of increasing length. In addition, subjects were presented with two matrices. An "arbitrary" matrix was composed of geometric shapes arranged in no special order. The other matrix, composed of geometric shapes arranged according to color and shape, was similar to those used by Piaget and Inhelder (1973) to study memory for double classifications. After viewing each array, the subjects were asked to reconstruct it from materials presented by the experimenter. Results indicated that performance of normal children on the "arbitrary" arrays was superior to that of the learning disabled children. Performance of normal and learning disabled children did not differ on the Piagetian tasks. Trepanier (1978) concluded that learning disabled and normal children with the requisite cognitive operations (i.e., seriation and classification) could use the operations to organize their memories. The learning disabled children in this study were considered to have deficits in the figurative but not the operative functions of memory.

Other Investigations of the Relationships Between Operativity and Memory

Students of constructive memory share Piaget's view of memory as "applied cognition." Constructive memory research began recently and has been concerned with operations such as inference, contextual mapping, elaboration, and integration which children and adults use to comprehend and interpret information (Paris, 1975: Paris and Lindauer, 1976, 1977).

Typical constructive memory research (Paris, 1975) has involved questioning children at different age levels about stories which have been read to them. Some answers can be provided by direct reference to the text, others can be supplied only by inference on the part of the child. Paris suggests ... "the ability to spontaneously apply inferential processes to discourse increases with age" (p. 9). The improved performance with age is attributed, partly, to an increased knowledge base and reasoning ability, i.e., Piagetian "memory in the wide sense," which develops as a result of interaction between the child and the environment.

Lunzer (1977) investigated the relationship between operativity, memory and language in young children. A test battery of Piagetian tasks (including classification tests), learning tasks, language tasks and memory tasks was administered to a large group of children aged five to six years. Lunzer reports that factor analysis of results indicated a multifactorial structure of abilities in these children. Among the factors which emerged were a language factor, operativity factor and several

memory factors. Correlation studies indicated significant relationships between operativity and memory and between operativity and language. Correlation between the former, however, was lower than correlation between the latter.

An investigation of classification as an organizing strategy for memory was carried out by Tomlinson-Keasey, Crawford and Eisert (1979). Children in kindergarten and grade one were designated as classifiers or nonclassifiers according to their performance on Piagetian class inclusion and hierarchical classification tests. Free recall of pictorial material representing categories of items familiar to young children was assessed.

Recall of the classifiers was superior to that of the nonclassifiers. Tomlinson-Keasey, Crawford and Eisert concluded that children with advanced classification skills organized items for recall more efficiently than those with less advanced classification skills.

Summary and Conclusions.

The theory and research presented in this chapter may be summarized as follows:

1. Piaget's theory of memory postulates a direct link between memory ability and cognitive development. According to Piaget, children at different stages of cognitive development remember stimuli differently. In addition, the individual child's memories will change in accordance with changes in the operational level of the child's cognitive development.

2. Replication studies of Piaget's original memory research have provided substantial support for an operative theory of memory.
3. Students of constructive memory share many of Piaget's views about memory. Constructivists have explored the ability of children and adults to interpret and make inferences from information presented in the form of oral stories. Results indicate that memory improves with age and depends to a great extent upon knowledge and cognitive actions.
4. Relationships between memory and operativity have been established by factor analytic studies (Lunzer, 1977) and by comparing the development of class inclusion skills with category clustering in free recall tests (Tomlinson-Keasey, Crawford and Eisert, 1979).

In conclusion, there is considerable support in the literature for an operative theory of memory. Piaget and others have supported the theory with experiments that suggest a positive relationship between the normal child's memory for a model representing a cognitive concept, i.e., seriation, and the child's operational level of performance on a task which directly demonstrates the concept, i.e., the construction of a seriated array. Trepanier (1978) suggests that this same relationship exists in learning disabled children.

Further understanding of the dependence of memory upon the level of development of the child's intellectual activities might

be obtained as follows. The levels of processing model of memory provides a means for studying the processes or strategies used by children to encode and retrieve information. Perhaps the model could be employed to relate the use of categorization (a strategy involved in semantic processing) to the level of cognitive development of classification structures from which, according to Piaget, the strategy is derived. The remaining chapters of this thesis describe a study designed to investigate the relationship between memory and classification abilities in achieving and learning disabled children.

CHAPTER V

THE STUDY

Introduction and Purpose

The literature suggests that the child's acquisition of classification concepts and memory abilities is developmental. Classification involves the ability to construct class hierarchies, and to understand the inclusion relations between the levels of the hierarchies. In the Piagetian view, the development of classification concepts proceeds through stages of pre-operational, concrete operational and, in some cases, formal operational behavior.

According to Inhelder and Piaget (1964) the ability to use progressively complex logical operations is the key factor which determines the order in which classification concepts are acquired. Class inclusion concepts, which involve the use of the logical quantifiers all and some and the permanent inclusion of the parts in the whole, are formed during the pre-operational and concrete operational periods of intellectual development. Mastery of inclusion relations is "logically prior" to the understanding of complementary classes to which concepts such as the singular class are closely linked. The null class is a concept placed at the borderline of concrete operational and formal operational thought, the Duality Principle includes a concept which extends into the formal operational period.

The memory ability of the child generally improves with age. Research suggests that the superior memory of older children is not

due to age-related changes in structural aspects of memory such as capacity of sensory stores and the short-term memory store (Chi, 1976; Cole, Frankel and Sharp, 1971). A number of investigations have provided some evidence that the superior memory abilities of older children can be attributed to: (1) an increased knowledge base (Brown, 1979; Chi, 1976, 1977); (2) more efficient use of memory capacity as demonstrated by conscious, versatile and systematic use of mnemonic strategies (Chi, 1976; Hagen, Jongeward and Kail, 1975; Moely, Olsen, Halwes and Flavell, 1969); and (3) the development of metamemorial skills (Kreutzer, Leonard and Flavell, 1975).

There is a growing tendency to think of memory in terms of "applied cognition" (Flavell, 1971). Information processing models of memory, such as the Craik and Lockhart (1972) levels of processing model, tend to emphasize control operations or mnemonic strategies used by the individual to encode and retrieve information. In the Craik and Lockhart memory model, the control operations are organized as a hierarchy of levels of processing, i.e., physical, phonemic and semantic.

It has been suggested that it might be possible to study the development of memory processes in children by merging a levels of processing model of memory with Piaget's theory of intellectual development (Brown, 1975; Reese, 1973, 1976). The control processes described in the memory model are interpreted as "structured cognitive operations." Features of the levels of processing approach to memory which make it attractive to

developmentalists are: (1) concern with mental operations or activities carried out by the subject at the time of stimulus encoding and decoding; and (2) the notion that memory involves the assimilation of incoming information to the subject's existing knowledge base (Brown, 1979). The present investigation employed the Craik and Lockhart (1972) levels of processing model of memory to relate children's use of categorization, a mnemonic strategy which appears to be involved in semantic processing, to their operative level of development of classification concepts (Inhelder and Piaget, 1964).

According to Craik and Lockhart (1972), when words are processed at the semantic level the subject makes use of rules and past knowledge. Information is assimilated to "existing cognitive structures." Given the typical orienting question, "Is this word a type of fruit?", and the stimulus word, "Peach," the writer hypothesizes that classification concepts are essential to the child's proper response. The "cognitive structure" to which the child assimilates the information may be the classification structure which, according to Piaget, develops in the child during the sensori-motor, pre-operational, concrete and formal operational periods of intellectual development.

Normal children presented with levels of processing tasks recall more words processed at the semantic level than at either the phonemic or physical levels (Snart, 1979, Geis and Hall, 1976; Owings and Baumeister, 1979). Kirkbride (1978a) found that learning disabled children recall more semantic level words than

phonemic or physical level words when presented with a levels of processing task.

Previous research (Kirkbride, 1977) suggests that the classification skills of learning disabled children develop in the same way as but at a slower rate than those of normal children of the same age level. In addition, an investigation by Kirkbride (1978a) suggests that learning disabled children do not perform as well on a levels of processing memory task as normal children at the same age level.

The main purpose of the present study was to determine whether a child who has well developed classification skills, as indicated by performance on Piagetian tasks, will perform better on a levels of processing memory task, in which categorization would appear to function as an appropriate encoding and retrieval strategy, than a child whose classification skills are less well developed. The sample population included achieving and learning disabled children at four different age levels (six to seven, eight to nine, 10 to 11 and 12 to 13 years). These particular age levels were chosen for two reasons. Piagetian research indicated that shifts from preoperational to concrete operational to formal operational thinking with respect to classification concepts occurred across these age levels. Memory research indicated that both recall ability and the use of mnemonic strategies increase as children grow older.

Results of a Pilot Study

To obtain some preliminary support for the investigation described here, a pilot study was carried out by Kirkbride (1978b).

The operative level of development of classification concepts in young children was compared with their performance on a levels of processing memory task. Achieving and learning disabled children at each of four age levels (six to seven, eight to nine, 10 to 11 and 12 to 13 years) participated in the study.

The test battery included five Piagetian classification tasks (Additive Composition of Classes, All and Some Conditions of Class Inclusion, Singular Class, Null Class and Duality Principle), and a levels of processing task. Following the memory task, the children were asked how they had remembered the words reported on the recall test. The number of categories mentioned by the children in their descriptions of their information retrieval processes was recorded.

Graphic representation of the pilot study data indicated that the total recall of children with well developed classification skills, as indicated by performance on the Piagetian tasks, was superior to that of children with less well developed classification skills. The performance of achieving children on both the classification and memory tasks was superior to that of learning disabled children at the same age level. Children who recalled more words also reported, during their interviews, that they had used more category labels as retrieval cues. There appeared to be a positive relationship between the development of classification skills and memory ability. (Details of the pilot study are given in Appendix A.) The design of the full scale comparative research study which was carried out to investigate the classification concepts and memory ability of achieving and learning disabled

children is discussed in the remaining sections of this chapter.

Selection Criteria for Subject Identification and Description of Sample

Three criteria were considered with respect to the selection of the sample population. The criteria were age, academic achievement, and IQ and the requirements for each are discussed separately.

Age Criteria

Twenty achieving and 20 learning disabled children at each of four age levels (six to seven, eight to nine, 10 to 11 and 12 to 13 years) were selected from children attending regular and special education classes in the Edmonton Public School System. Children assigned to each of these age levels were no younger than six, eight, 10 or 12 years and no older than seven years six months, nine years six months, 11 years six months or 13 years six months. There were two exceptions to this general rule. One learning disabled child assigned to the 10 to 11 year old group was nine years 11 months old, and one learning disabled child assigned to the 12 to 13 year old group was 11 years 11 months old. Mean ages in months for children at each of the different age levels were as follows: six to seven years, achievers 79.9, learning disabled 80.2; eight to nine years, achievers 105.7, learning disabled 104.3; 10 to 11 years, achievers, 129.2, learning disabled 127.3; and 12 to 13 years, achievers 151.9, learning disabled, 150.6. Sex and chronological age characteristics of the subjects are presented in Table 1.

Table 1

Description of Sex, Chronological Age and IQ Characteristics of Subjects (N=160)

Group	C.A. Level* (years)	Sex		C.A. Characteristics			I Q Characteristics									
							PPVT			Other IQ Measure						
										Verbal			Performance			Test
		M	F	Range (months)	$\bar{X}$	s.d.	Range	$\bar{X}$	s.d.	Range	$\bar{X}$	s.d.	Range	$\bar{X}$	s.d.	
Achievers	6-7	12	8	74-87	79.9	3.57	91-129	107.1	10.85							not available
	8-9	11	9	98-113	105.7	3.79	91-129	111.6	9.17	92-119	109.4	6.32	90-117	103.6	7.26	CCAT, N=20
	10-11	12	8	122-134	129.2	3.19	100-124	108.4	6.83	100-122	113.2	5.72	101-122	110.6	6.27	CCAT, N=20
	12-13	10	10	146-156	151.9	3.34	98-126	112.5	7.73	100-114	106.3	4.88	99-115	107.8	4.42	LT, N=20
Learning Disabled	6-7	10	10	74-86	80.2	4.01	85-121	104.4	9.66							not available
	8-9	16	4	96-113	104.3	5.43	85-126	106.3	12.48	80-114	99.3	10.98	81-120	100.00	12.00	WISC-R, N=15**
	10-11	12	8	119-134	127.3	4.59	89-113	100.5	6.58	81-109	93.1	9.31	81-115	100.1	11.13	WISC-R, N=19
	12-13	12	8	143-158	150.6	4.85	88-120	100.3	7.31	85-110	94.0	5.23	85-118	104.1	10.41	WISC-R, N=20

*There were 20 achieving and 20 learning disabled children at each age level.

**Three other subjects in this group had Binet scores of 85, 87 and 90.

Academic Achievement Criteria

The youngest children, i.e., six to seven years of age, were selected for the project by their grade one teachers. The achievers were experiencing no problems with grade one learning tasks. The learning disabled children were characterized as experiencing numerous problems with early learning tasks particularly in areas related to reading, i.e., auditory discrimination, pattern matching and school language, etc. Twelve of these young children with learning difficulties were receiving reading tuition in a resource room, the remaining children were being given special assistance in reading by their homeroom teachers.

The three older groups of achieving children were selected on the basis of their performance on standardized tests of reading and mathematics, i.e., the Edmonton Public School Board Reading Test and the Edmonton Public School Board Mathematics Test. These tests had been administered to the children by school personnel six months prior to the selection of subjects for this investigation. Achievement test scores for the subjects were at or above the 30th percentile for each of the reading abilities tested and, with few exceptions, scores were at or above the school system raw score mean for mathematics. Representatives of the Edmonton Public School Board testing and evaluation department had advised the experimenter that children scoring above these limits were usually able to cope with academic work appropriate to their grade level. In all cases, the current academic performance of the achieving children selected in this way was verified as adequate by their

homeroom teachers before the children were included in the study. Specific details of performance on the standardized tests by achieving children at the three older age levels are summarized in Table 2. Several children for whom achievement test scores were not available were included in the study upon the recommendation of their homeroom teachers.

The three older groups of learning disabled children were selected from special education classes designed for children of normal intellectual potential experiencing severe academic and, in some cases, behavior problems. An academic deficit, manifested by performance which is at least one year below that expected in reading or mathematics or both with respect to the age and expected grade level of the child, must be demonstrated before children are assigned to the special education classes described here.

No child whose academic problems (in the opinion of school personnel) stemmed primarily from a behavior disorder was included in the study. All of the learning disabled children in the three older age groups were experiencing reading problems. Their reading deficits were generally in the order of at least one to two years below the performance that could be expected from children of their age and expected grade level. Many of the children had problems with mathematics which were secondary to their reading disabilities, i.e., they had difficulty reading mathematical problems.

The academic deficits of the learning disabled children were verified by the experimenter through consultation with their homeroom teachers, resource teachers and counsellors. School

Table 2

Performance on Standardized Tests by Achieving Children at Age Levels 8 to 9, 10 to 11, and 12 to 13 Years

Age Level (Years)	Standardized Reading Test				Standardized Mathematics Test			
	Ability Tested	Percentile			Raw Score **			
		Range	$\bar{X}$	N*	Range	$\bar{X}$	s.d.	N*
8 to 9	Decoding	30 - 98	67	18	50 - 60	56.9	3.3	16
	Comprehension	30 - 84	61	17				
10 to 11	Word meaning	49 - 92	72	20	40 - 55	48.6	4.3	20
	Paragraph meaning	36 - 90	71	20				
	Word study skills	40 - 96	75	20				
12 to 13	Decoding	30 - 96	62	20	37 - 55	44.8	5.5	19
	Comprehension	35 - 94	64	20				

*When N < 20, standardized test scores were not available for children included in the study.

**School system raw score means and standard deviation for these age levels were: 8 to 9 57.9±6.8; 10 to 11, 42.9±10.1; 12 to 13, 39±11.1

personnel and test reports contained in the children's cumulative records suggested that many of the children demonstrated various types and degrees of visual and/or auditory perceptual problems, visual-motor integration problems, spatial disorders and linguistic difficulties. The sample population of learning disabled children was homogeneous in that all of the children had reading disabilities, but the population was heterogeneous with respect to factors which may have been contributing to the reading disabilities.

IQ Criteria

Whenever possible, IQ scores were obtained for children participating in the project. Verbal and non-verbal or performance IQ scores of 85+ (on either individual or group tests of intelligence) were considered indicative of normal intellectual ability. School records provided IQ scores for most of the children included in the study except those at the youngest age level. The Peabody Picture Vocabulary Test (Dunn, 1959, 1965), which was used in the study as a screening instrument, provided an estimate of the verbal intelligence of the children at the six to seven year age level. The Peabody Test also provided a common measure of verbal intelligence for all of the children involved in the study.

IQ scores for the three older groups of achieving children were obtained from school records of group intelligence tests. Test scores on the Canadian Cognitive Abilities Test were available for children at the eight to nine and 10 to 11 year age levels, and scores on the Lorge Thorndike Intelligence Test were available for

children at the 12 to 13 year age level.

It should be mentioned that the published test means for verbal and non-verbal performance on the Canadian Cognitive Abilities Test and Lorge Thorndike Intelligence Test are 100 with a standard deviation of 15. In all cases, the Edmonton Public School System means for these tests were higher than the published means, i.e., for the eight to nine age group, verbal $\bar{X} = 108.7 \pm 14.6$, non-verbal $\bar{X} = 103.5 \pm 15.5$; and for the 10 to 11 age group, verbal $\bar{X} = 107.4 \pm 15.3$ and non-verbal, $\bar{X} = 103.6 \pm 16.2$; and for the 12 to 13 age group, verbal $\bar{X} = 101.8 \pm 15.1$ and non-verbal $\bar{X} = 109.5 \pm 16.6$. In the schools assigned to the experimenter for this investigation, it was not usually possible to select students much below the school system means for IQ if the performance criteria required on the standardized achievement tests were to be met. The academic performance of the majority of achieving children included in this study was considered as average by their teachers.

IQ scores on individual tests of intelligence, either the Wechsler Intelligence Scale for Children - Revised (WISC-R) or the Stanford Binet, were available for the majority of learning disabled children at the three older age levels. Verbal and performance scores of 85+ on these tests were generally required for children participating in the study. Several children with a verbal or performance score between 80 and 85 were included in the study. In such instances, if either the verbal or performance score was less than 85, the other was greater than 85.

In addition, the score obtained by these children on the Peabody Picture Vocabulary Test was either above or less than one standard deviation below the mean, i.e., 100 ± 15. With respect to 54 WISC-R scores available for learning disabled children in the three older age groups: verbal scores were higher than performance scores by 10 or more points in four cases performance scores were higher than verbal scores by 10 or more points in 24 cases; and verbal and performance scores did not vary by 10 or more points in 26 cases. Details regarding the IQ characteristics of achieving and learning disabled children participating in the study are found in Table 1.

The Test Battery

The test battery included five Piagetian classification tasks and a levels of processing memory task. The classification tasks were (1) Additive Composition of Classes, (2) All and Some Conditions of Class Inclusion, (3) the Singular Class, (4) the Null Class, and (5) the Duality Principle. Two forms of the Duality Principle task were employed in the study. The form used in the majority of cases was one which tested the child's understanding of the inclusion relations between the classes and subclasses of an animal hierarchy, i.e., ducks < birds < animals. In situations where children did not agree that birds were animals etc., an alternative form of the task involving the classification of flowers was used.

The classification tasks were developed by Whyte (1967) from descriptions given by Inhelder and Piaget (1964). The levels of

processing task, developed by Lupart (1978), was based on a procedure used by Craik and Tulving (1975). A complete description of the tasks and appropriate administration procedures is found in Appendix B.

Procedure

The experimenter tested children individually in a private room at their own school. A number of immigrant children attended the schools assigned to the experimenter for the study. The Peabody Picture Vocabulary Test was used as a screening device to exclude children whose receptive vocabulary deficiencies were due to English as a second language. The test battery was administered to each child in the following order: (1) Levels of Processing task, (2) Additive Composition of Classes, (3) All and Some Conditions of Class Inclusion, (4) Singular Class, (5) Null Class, and (6) Duality Principle.

Following the levels of processing task, the children were asked how they had remembered the words reported on the recall test. The experimenter recorded the children's comments, and noted the category labels they mentioned during explanation of their memory processes. Any category lables not mentioned were suggested by the experimenter, and the children were asked if they could remember any words belonging to those categories. A cued recall score was thus obtained for each subject.

Tape recordings of interviews with some of the children were obtained. Unfortunately, circumstances such as noise (bells ringing, classes changing, band practice), technical difficulties (lack

of electrical outlets), and the distracting influence of the tape recorder on some of the children prevented the taping of all of the interviews.

Questions for Investigation

The study was designed to investigate questions related to the development of Piagetian classification concepts, performance on the levels of processing task, and the relationship between the development of classification concepts and performance on the memory task.

Questions Related to the Development of Piagetian Classification Concepts

1. Is there a significant relationship between the age level of achieving children and stage of development on each of the five Piagetian tasks?
2. Is there a significant relationship between the age level of learning disabled children and stage of development on each of the five Piagetian tasks?
3. Is there a significant relationship between diagnostic group and stage of development on each of the five Piagetian tasks with respect to achieving and learning disabled children at the same age level?
4. Is there evidence to support the concept of a developmental lag with respect to the age level at which learning disabled children acquire the five Paigetian classification concepts compared with achieving children?

5. Is there any evidence which indicates a priority of order of acquisition of the five Piagetian concepts by achieving and learning disabled children?

Questions Related to Performance on the Levels of Processing Task

1. Is memory developmental within the population of achieving children; do older children recall more words than younger children?
2. Is memory developmental within the population of learning disabled children; do older children recall more words than younger children?
3. Is the total recall of achieving children superior to that of learning disabled children at the same age level?
4. Will the recall scores obtained by achieving and learning disabled children at four different age levels support the Craik and Lockhart (1972) position, that on a test of recall for words processed at physical, phonemic, and semantic levels, the hierarchy of recall will be semantic > phonemic > physical?
5. Will the interview information provide any indications as to how both the achieving and learning disabled children retrieve from memory the stimulus words involved in the levels of processing task?
6. Following spontaneous recall, will achieving and learning disabled children effectively use cues, provided in the form of category labels, to recall more words?

Questions Regarding the Relationship Between the Development of the Piagetian Classification Concepts and Recall on the Levels of Processing Task

1. Will recall on the memory task by achieving and learning disabled children increase as the stage of development on the classification tasks increases?
2. Will the recall of achieving and learning disabled children who are at the same stage of development on the same classification tasks differ?

Limitations of the Study

The study was limited in three major areas. The first involved the selection criteria for the subjects. One hour of testing time was required to administer the screening instrument and test battery and to interview each child. Consequently, it was not practical to administer a common group test of intelligence and common standardized achievement tests to all of the participants in the study. It was necessary, therefore, to rely initially upon the accuracy and validity of the test results available from the Edmonton Public School Board, and finally upon the verification of the subjects' current academic performance and emotional status by teachers and other school personnel.

The second area in which the study was limited involved the small number of subjects tested at each different age level. The results obtained may be useful in indicating trends that exist with regard to the performance of the population of achieving and learning disabled children described here and thus suggest possibilities

for further research in order to verify the results with much larger populations.

The third major area of limitation of this investigation involved the composition of the population of learning disabled children. The population was homogeneous in that all the children had reading problems. The population was heterogeneous, however, in that both test results and school personnel suggested that various perceptual and linguistic deficits might be contributing to the reading difficulties the children were experiencing. The findings of this investigation may be applicable to learning disabled children as a group. It may not be possible to generalize from the results to account for the problems of individual learning disabled children.

CHAPTER VI

RESULTS

The results of this investigation will be presented in four sections. The first section will summarize the analysis of the chronological age and IQ data. The second section will describe the analysis of the Piagetian task data. In the third section, the recall results obtained on the levels of processing memory task will be presented. The fourth section will deal with the procedures used to search for relationships between the operative level of the subjects, as indicated by their performance of the Piagetian classification tasks, and their memory ability.

The Results of the Analysis of Chronological Age and IQ Data

The mean ages, in months, of achieving and learning disabled children at each of the four different age levels were as follows: six to seven years, achievers 79.9, learning disabled 80.2; eight to nine years, achievers 105.7, learning disabled 104.3; 10 to 11 years, achievers 129.2, learning disabled 127.3; and 12 to 13 years, achievers 151.9, learning disabled 150.6. Two-way analysis of variance 2 (groups) x 4 (age levels) of the subjects' chronological age data indicated a significant main effect for age levels, $F(3,152) = 2161.05$, $p<.001$. The main effect for groups and the interaction between groups and age levels were not significant ($p>.05$). Tukey (a) procedures (Linton and Gallo, Jr., 1975) were used to make multiple comparisons of the means involved in the main effect for age levels. Significant differences ($p<.01$) were

detected between all of the age levels.

It was not possible to use statistical methods to compare the IQ scores obtained from school records for achieving and learning disabled children participating in the study. Statistical comparisons could not be made because the IQ scores of achieving children had been derived from group tests of intelligence while those of learning disabled children had been derived from individual intelligence tests. The IQ data obtained from school records has been described in detail in Table 1 and discussed in the preceding chapter.

The Peabody Picture Vocabulary Test (PPVT) provided a common measure of verbal intelligence for all of the subjects. The mean PPVT scores of achieving and learning disabled children at each of the four different age levels were as follows: six to seven years, achievers 107.1, learning disabled 104.4; eight to nine years, achievers 111.6, learning disabled 106.3; 10 to 11 years, achievers 109.4, learning disabled 100.5; and 12 to 13 years, achievers 112.5, learning disabled 100.3.

Two-way analysis of variance 2 (groups) x 4 (age levels) of the subjects' PPVT scores indicated a main effect for groups $F\ (1,152)=25.80$, $p<.001$. The average verbal IQ of 110.1 for achievers was superior to the average verbal IQ of 102.9 for learning disabled children.

The two-way analysis of variance did not indicate a significant main effect for age levels or a significant groups x age levels interaction. Probability in both cases was greater than .05.

Tukey (a) tests indicated significant differences between the average IQs of achieving and learning disabled children at the 10 to 11 year age level ($p<.05$) and the 12 to 13 year age level ($p<.01$). The average IQ of achieving and learning disabled children at both the six to seven and eight to nine year age levels did not differ significantly ($p<.05$).

The Results of the Analysis of the Piagetian Classification Task Data

The stage of development for each child on each of the five Piagetian tasks was determined. A full description of the criteria for placement in the various stages is provided in Appendix C. The numbers of achieving and learning disabled children at each of the four age levels (six to seven, eight to nine, 10 to 11, and 12 to 13 years) who were at each stage of development on the five classification tasks are presented in Table 3.

The percentages of achieving and learning disabled children at each age level demonstrating performance at each developmental stage of each task were calculated. This information is presented graphically as follows: Figure 2, sections (a) through (h), Additive Composition of Classes; Figure 3, sections (a) through (h), All and Some Conditions of Class Inclusion; Figure 4, sections (a) through (h), Singular Class; Figure 5, sections (a) through (h), Null Class; and Figure 6, sections (a) through (h), Duality Principle.

The Piagetian data were subsequently analyzed: (1) to detect relationships in both achieving and learning disabled children

Table 3

Numbers of Achieving and Learning Disabled Children at each Stage of Development on Five Piagetian Classification Tasks

Age Level (years)	Group	Additive Composition			All and Some			Singular Class				Null Class				Duality Principle			
		Stage			Stage			Stage				Stage				Stage			
		1	2	3	1	2	3	1a	1b	2	3	1	2	3	4a	1	2	3	4
6 - 7	A	6	9	5	0	8	12	4	6	5	5	0	11	4	5	6	14	0	0
	LD	12	6	2	1	13	6	13	7	0	0	5	14	1	0	12	8	0	0
8 - 9	A	1	6	13	0	9	11	0	6	5	9	0	1	9	10	0	17	3	0
	LD	8	6	6	1	10	9	8	8	2	2	2	11	5	2	6	14	0	0
10 - 11	A	0	1	19	0	2	18	0	0	2	18	0	0	3	17	0	5	12	3
	LD	4	6	10	0	6	14	4	9	4	3	0	4	9	7	3	14	3	0
12 - 13	A	0	0	20	0	0	20	0	0	0	20	0	0	4	16	0	0	6	14
	LD	0	2	18	0	4	16	0	5	5	10	0	4	6	10	1	13	5	1

(N = 20 Achieving (A) and 20 Learning Disabled (LD) at Each Age Level)

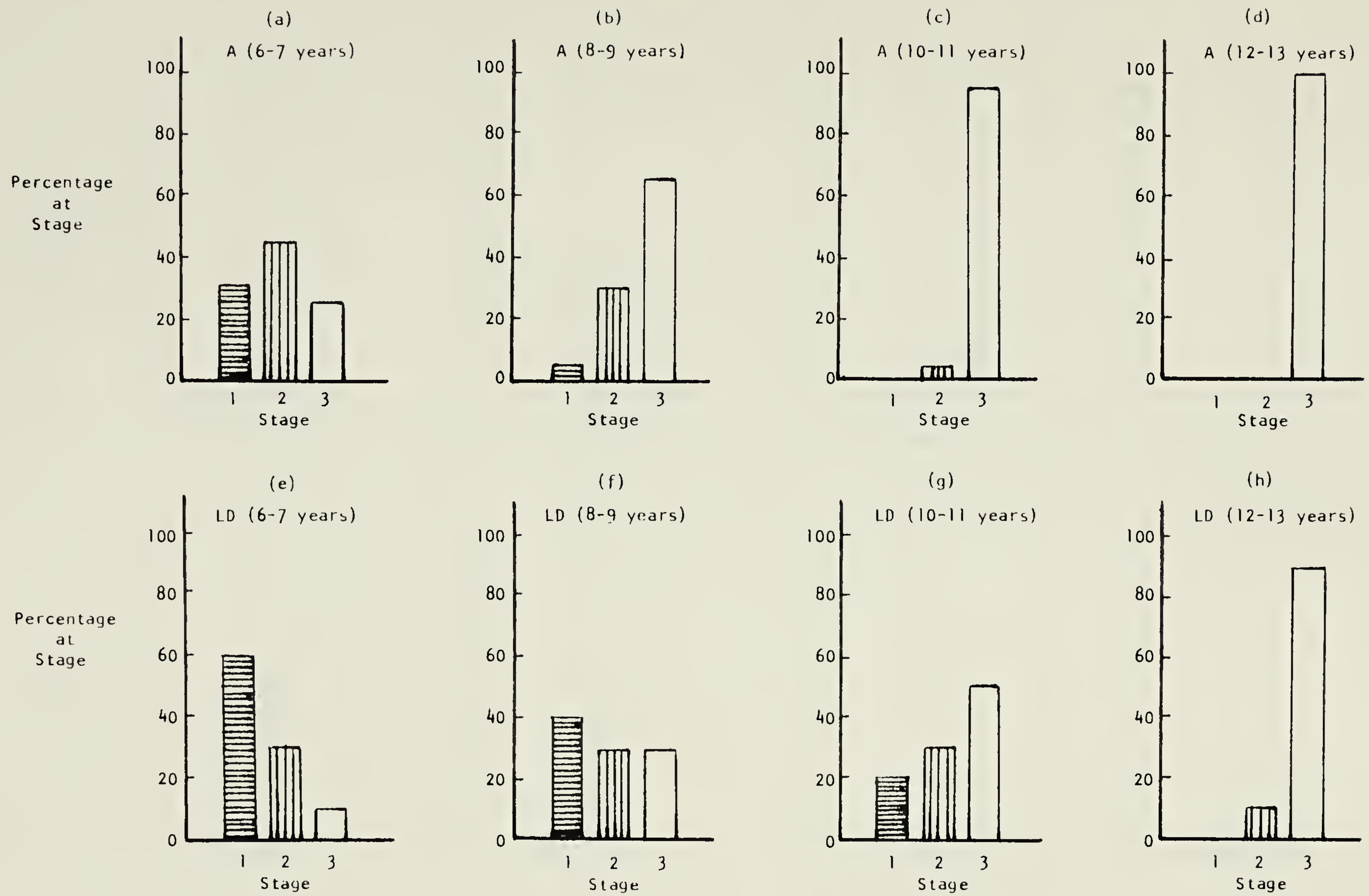

Figure 2. Percentages of Achieving (A) and Learning Disabled (LD) Children at Four Age Levels Demonstrating Different Stages of Performance on the Additive Composition of Classes Task.

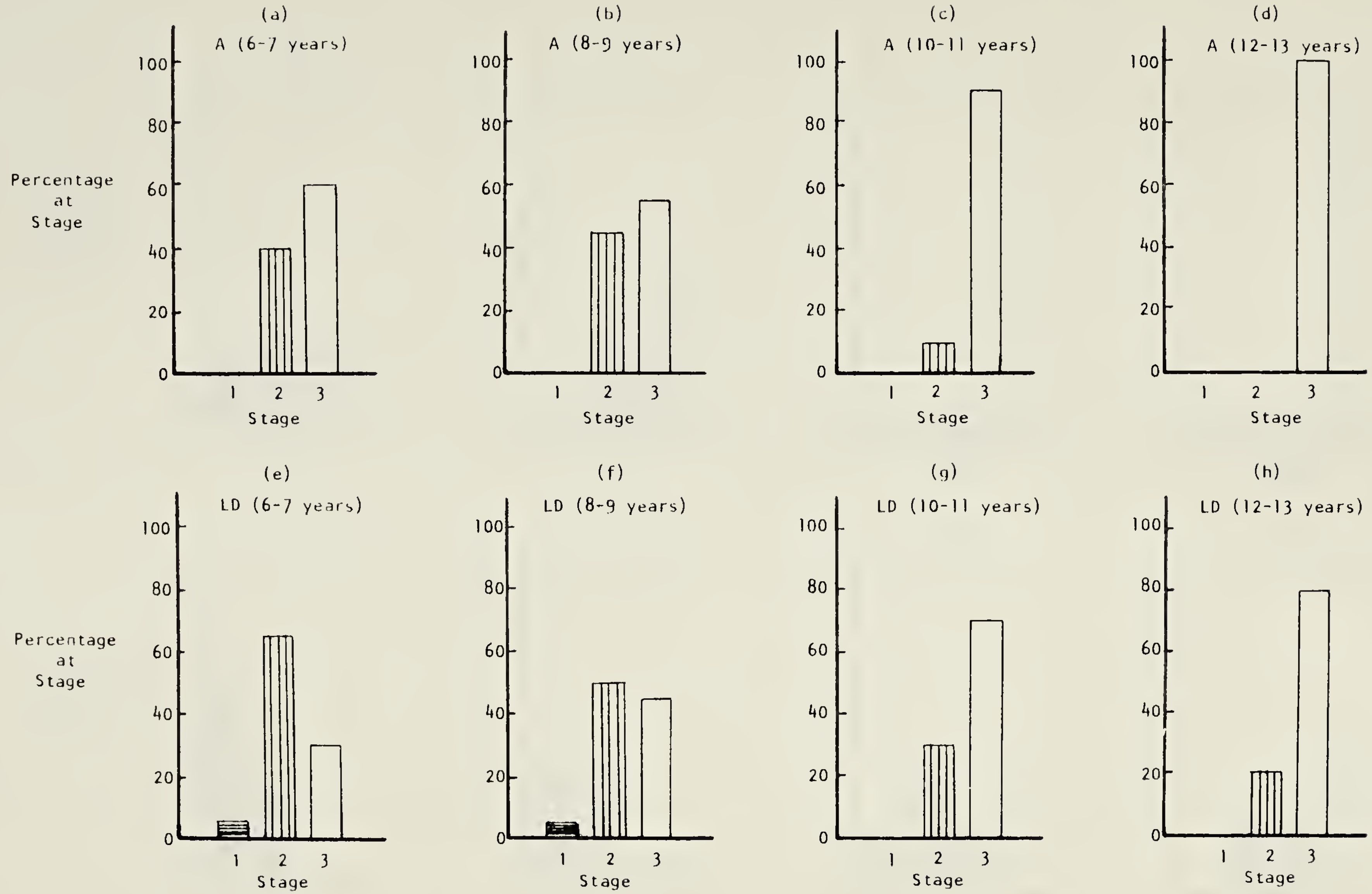

Figure 3. Percentages of Achieving (A) and Learning Disabled (LD) Children at Four Age Levels Demonstrating Different Stages of Performance on the "All" and "Some" Task.

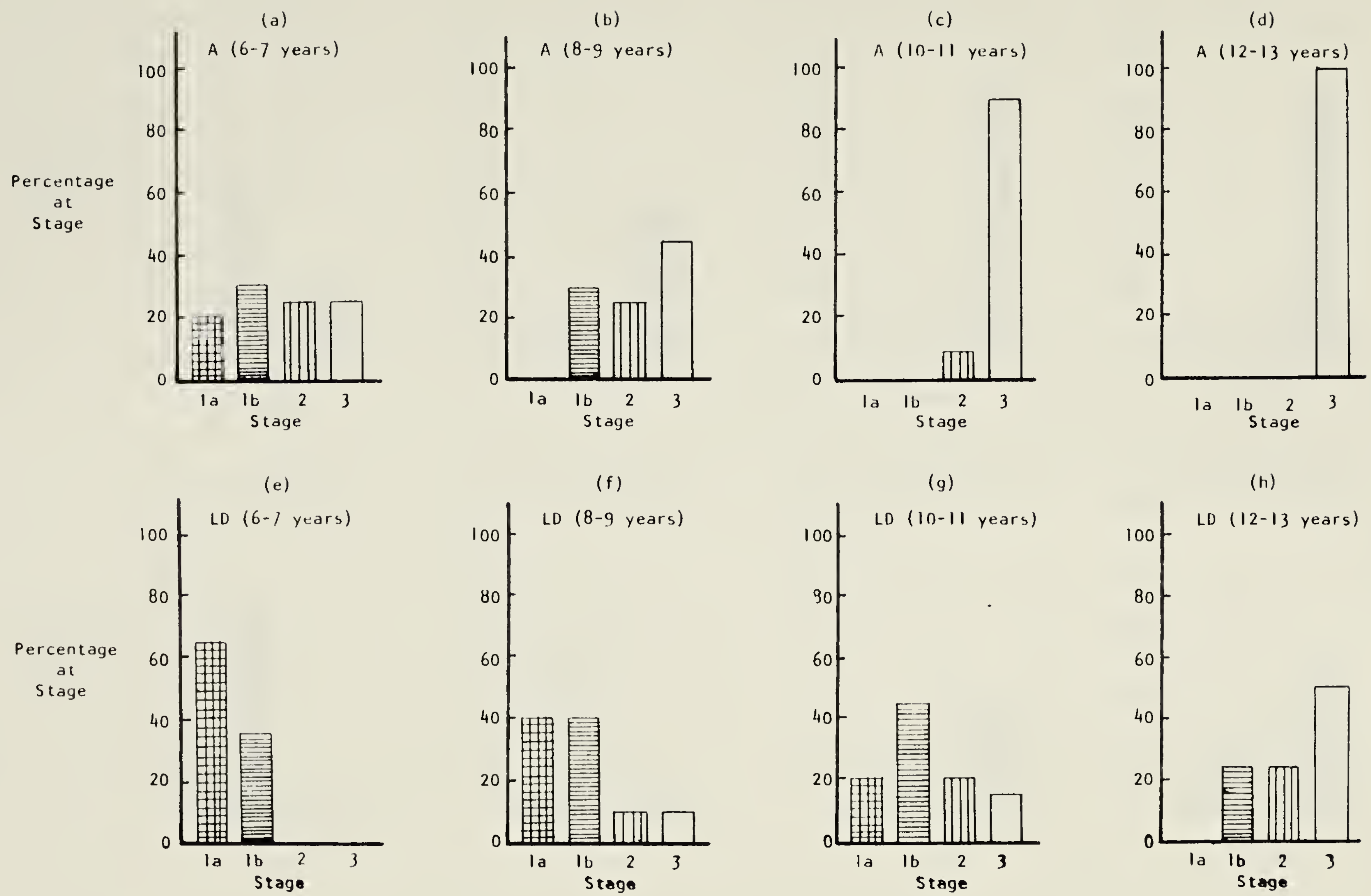

Figure 4. Percentages of Achieving (A) and Learning Disabled (LD) Children at Four Age Levels Demonstrating Different Stages of Performance on the Singular Class Task.

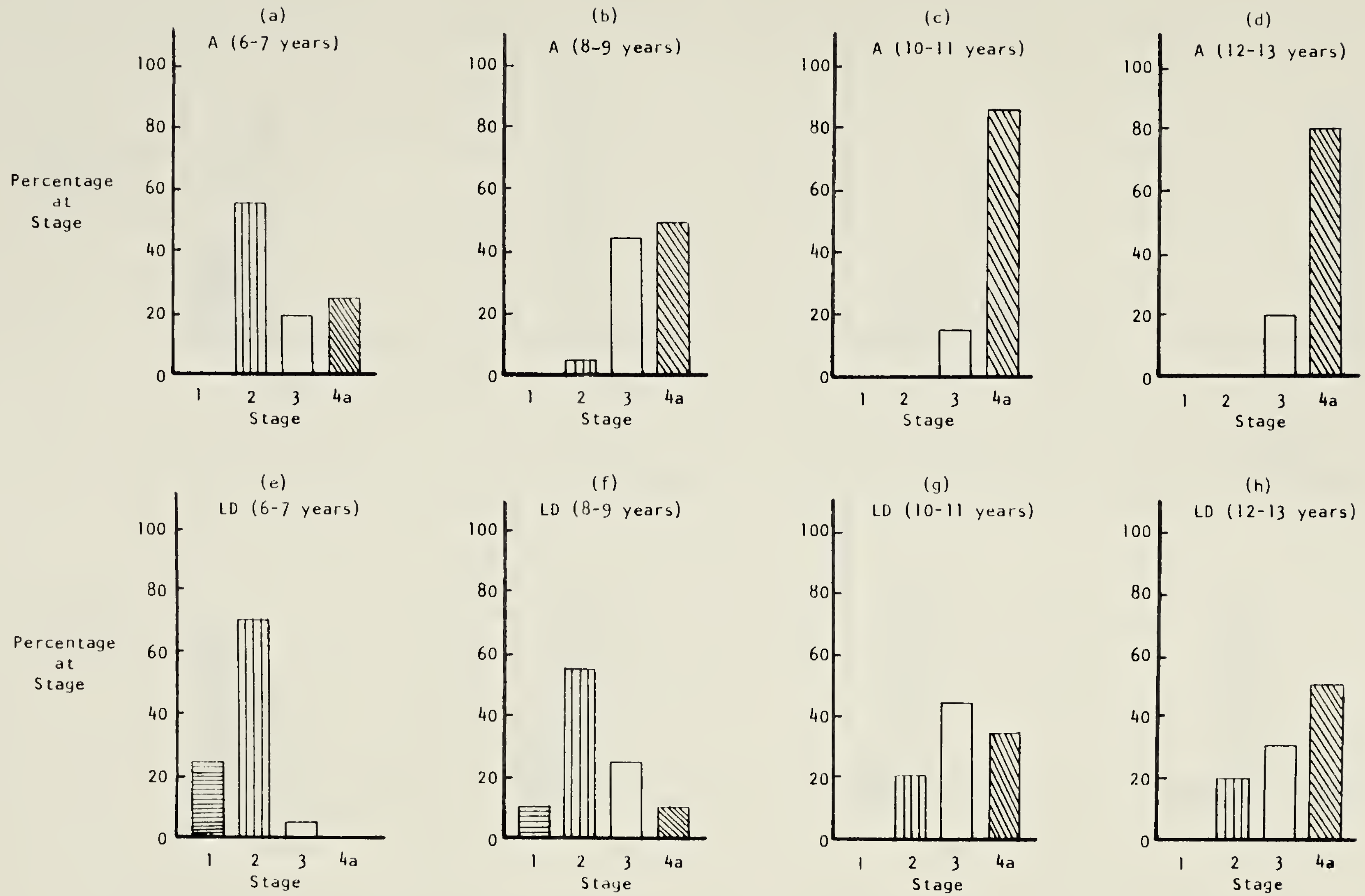

Figure 5. Percentages of Achieving (A) and Learning Disabled (LD) Children at Four Age Levels Demonstrating Different Stages of Performance on the Null Class Task.

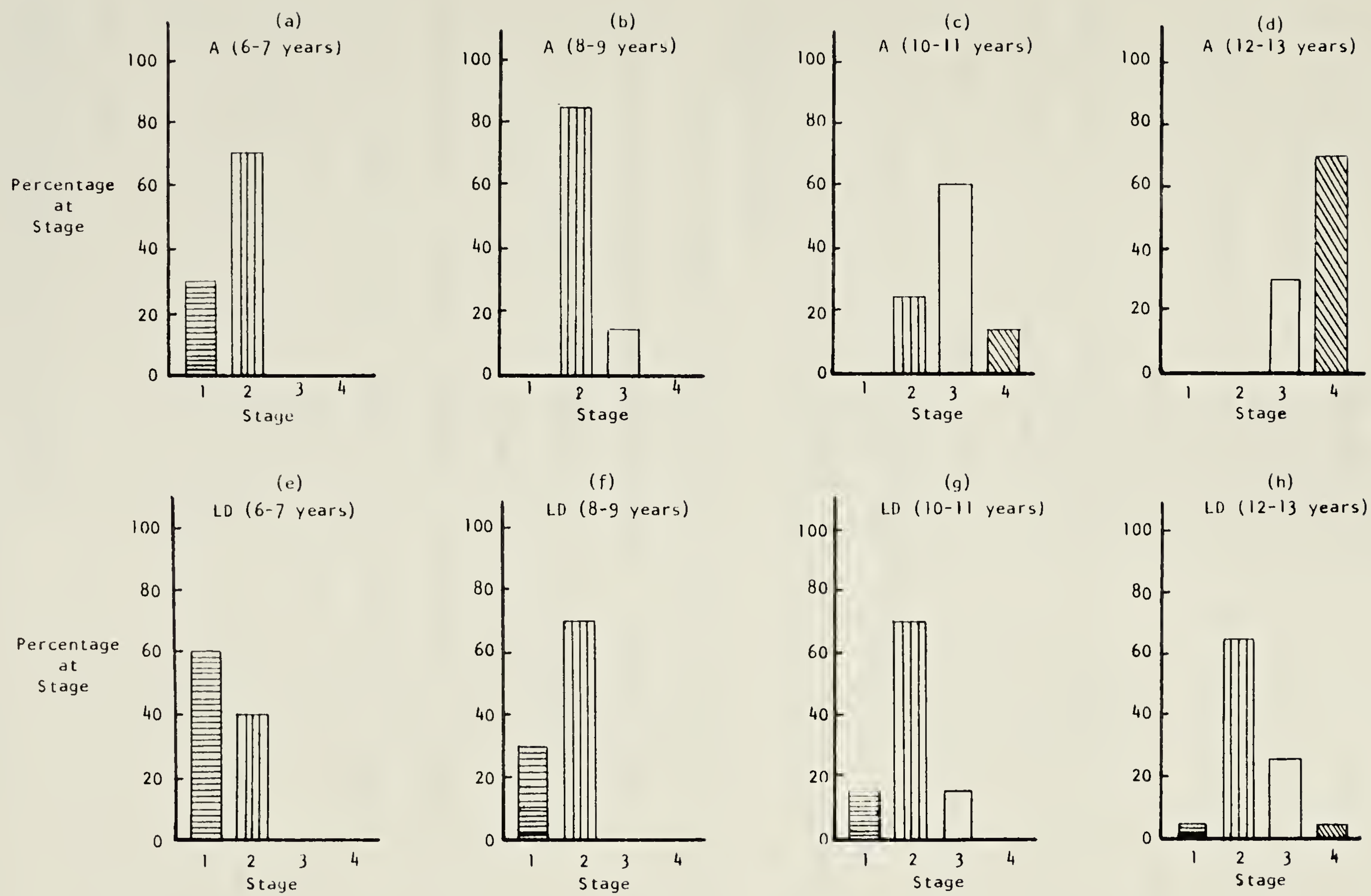

Figure 6. Percentages of Achieving (A) and Learning Disabled (LD) Children at Four Age Levels Demonstrating Different Stages of Performance on the Duality Principle Task.

between age level and stage of development on the Piagetian tasks; (2) to detect relationships between diagnostic group and stage of development on the Piagetian tasks for achieving and learning disabled children at the same age level; (3) to detect the existence of a developmental lag in the learning disabled children with respect to the acquisition of the Piagetian classification concepts. In addition, the data were (4) examined for evidence that children demonstrate an operational level of performance, i.e., concrete or formal operational performance, on a particular task or combination of tasks prior to others. The results of the procedures used for these purposes will be discussed separately.

Relationship Between Age Level and Stage of Development on the Piagetian Tasks

The Chi Square statistic was used to determine whether significant relationships existed between the age levels of the subjects and their stage of development on the Piagetian tasks. The Chi Square comparisons of the numbers of achieving children at four different age levels, who were at different stages of development on the classification tasks, are presented in Table 4. The same information for the learning disabled children is found in Table 5. When differences were significant ($p<.05$), the performance of the older children was superior. Specific differences are given for each task.

Additive Composition of Classes

Chi Square comparisons of achieving children on the Additive Composition of Classes task indicated that the performance of the

Table 4

Chi Square Comparisons of Stage Performance of Achieving Children of Different Age Levels on Five Piagetian Tasks

Task	Age Level Comparison (years)	Chi Square	df	p
Additive Composition	6- 7 and 8- 9	7.7270	2	0.021*
	6- 7 and 10-11	20.5667	2	0.000***
	6- 7 and 12-13	24.0000	2	0.000***
	8- 9 and 10-11	5.6964	2	0.058
	8- 9 and 12-13	8.4849	2	0.014*
	10-11 and 12-13	0.0000	1	1.000
All and Some	6- 7 and 8- 9	0.0000	1	1.000
	6- 7 and 10-11	3.3333	1	0.068
	6- 7 and 12-13	7.6563	1	0.006**
	8- 9 and 10-11	4.5141	1	0.034*
	8- 9 and 12-13	9.1756	1	0.003**
	10-11 and 12-13	0.5263	1	0.468
Singular Class	6- 7 and 8- 9	5.1429	3	0.162
	6- 7 and 10-11	18.6334	3	0.000***
	6- 7 and 12-13	24.0000	3	0.000***
	8- 9 and 10-11	10.2857	2	0.006**
	8- 9 and 12-13	15.1724	2	0.001***
	10-11 and 12-13	0.5263	1	0.468
Null Class	6- 7 and 8- 9	11.9231	2	0.003**
	6- 7 and 10-11	17.6883	2	0.000***
	6- 7 and 12-13	16.7619	2	0.000***
	8- 9 and 10-11	5.8148	2	0.055
	8- 9 and 12-13	4.3077	2	0.116
	10-11 and 12-13	0.0000	1	1.000
Duality Principle	6- 7 and 8- 9	9.2903	2	0.010**
	6- 7 and 10-11	25.2632	3	0.000***
	6- 7 and 12-13	40.0000	3	0.000***
	8- 9 and 10-11	14.9455	2	0.001***
	8- 9 and 12-13	32.0000	2	0.000***
	10-11 and 12-13	14.1177	2	0.001***

*$p \leq .05$

**$p \leq .01$

***$p \leq .001$

Table 5

Chi Square Comparisons of Stage Performance of Learning Disabled Children of Different Age Levels on Five Piagetian Tasks

Task	Age Level Comparison (years)	Chi Square	df	p
Additive Composition	6- 7 and 8- 9	2.8000	2	0.247
	6- 7 and 10-11	10.8103	3	0.005**
	6- 7 and 12-13	26.8000	2	0.000***
	8- 9 and 10-11	3.3497	2	0.187
	8- 9 and 12-13	16.0000	2	0.000***
	10-11 and 12-13	8.0635	2	0.018*
All and Some	6- 7 and 8- 9	0.9913	2	0.609
	6- 7 and 10-11	6.7790	2	0.034*
	6- 7 and 12-13	10.3102	2	0.006**
	8- 9 and 10-11	3.0870	2	0.214
	8- 9 and 12-13	5.5314	2	0.063
	10-11 and 12-13	0.1333	1	0.715
Singular Class	6- 7 and 8- 9	5.2571	3	0.154
	6- 7 and 10-11	12.0147	3	0.007**
	6- 7 and 12-13	28.3333	3	0.000***
	8- 9 and 10-11	2.2588	3	0.521
	8- 9 and 12-13	15.3114	3	0.002**
	10-11 and 12-13	9.0232	3	0.029*
Null Class	6- 7 and 8- 9	6.3124	3	0.097
	6- 7 and 10-11	23.9556	3	0.000***
	6- 7 and 12-13	34.1270	3	0.000***
	8- 9 and 10-11	9.1873	3	0.027*
	8- 9 and 12-13	10.6909	3	0.014*
	10-11 and 12-13	1.1294	2	0.569
Duality Principle	6- 7 and 8- 9	2.5253	1	0.112
	6- 7 and 10-11	10.0364	1	0.007**
	6- 7 and 12-13	16.4982	2	0.001***
	8- 9 and 10-11	4.000	2	0.135
	8- 9 and 12-13	9.6085	3	0.022*
	10-11 and 12-13	2.5370	3	0.469

*$p \leq .05$

**$p \leq .01$

***$p \leq .001$

six to seven year olds was inferior to that of the eight to nine ($p<.05$), 10 to 11 ($p<.001$), and 12 to 13 ($p<.001$) year olds. The eight to nine year olds did not perform as well on this task as the 12 to 13 year olds ($p<.05$). No significant differences in performance were found between the eight to nine and 10 to 11 year olds or between the 10 to 11 and 12 to 13 year olds.

Within the population of learning disabled children, performance on the Additive Composition of Classes task by children at the six to seven year level was inferior to that of children at both the 10 to 11 ($p<.01$) and 12 to 13 ($p<.001$) year levels. In addition, the performance of 12 to 13 year olds was superior to that of both the eight to nine ($p<.001$) and 10 to 11 ($p<.05$) year olds. No significant performance differences were found between the six to seven and eight to nine year olds or between the eight to nine and 10 to 11 year olds.

<u>All and Some Conditions of Class Inclusion</u>

Chi Square results for achieving children on the All and Some Conditions of Class Inclusion task indicated significant differences in performance between the six to seven and 12 to 13 year olds ($p<.01$). The performance of the eight to nine year olds differed significantly from that of both the 10 to 11 ($p<.05$) and the 12 to 13 ($p<.01$) year olds. In all of these cases the performance of older children was superior to that of younger children. No significant performance differences were found between the six to seven and either the eight to nine or the 10 to 11 year olds. In addition, the performance of the 10 to 11 and 12 to 13 year olds

did not differ significantly.

Learning disabled children at the six to seven year level performed less well than those at both the 10 to 11 year level ($p<.05$) and the 12 to 13 year level ($p<.01$) with respect to the All and Some Conditions of Class Inclusion task. No significant performance differences were observed for this task between learning disabled children at the following age levels: six to seven and eight to nine years; six to seven and 10 to 11 years; and 10 to 11 and 12 to 13 years.

The Singular Class

Within the population of achieving children, the performance of six to seven year olds differed significantly from that of 10 to 11 and 12 to 13 year olds ($p<.001$) on the Singular Class task. The performance of eight to nine year olds also differed significantly from that of the 10 to 11 ($p<.01$) and 12 to 13 ($p=.001$) year olds. In all cases, the performance of older children was superior. No differences were observed between the performance of six to seven and eight to nine year olds or between that of 10 to 11 and 12 to 13 year olds on the Singular Class task.

Among the different age level groups of learning disabled children, the Chi Square values for the Singular Class were significant between the six to seven year olds and both the 10 to 11 ($p<.01$) and the 12 to 13 ($p<.001$) year olds. The performance of the eight to nine year olds as well as that of the 10 to 11 year olds differed significantly from that of the 12 to 13 year olds ($p<.01$, $p<.05$, respectively). The performance of older children

was superior to that of younger children. No significant performance differences for the Singular Class were observed between learning disabled children at the six to seven and eight to nine year age levels or between those at the eight to nine and 10 to 11 year age levels.

The Null Class

For the Null Class, the Chi Square comparisons indicated that the performance of the six to seven year old achievers was inferior to that of eight to nine ($p<.01$), 10 to 11 ($p<.001$), and 12 to 13 ($p<.001$) year old achievers. The performance of eight to nine year olds did not differ significantly from that of either the 10 to 11 or 12 to 13 year olds; nor did the performance of 10 to 11 and 12 to 13 year olds differ significantly with respect to the Null Class task.

The performance of learning disabled children at the six to seven year age level differed significantly from that of children at both the 10 to 11 and 12 to 13 year age levels ($p<.001$) on the Null Class task. Significant differences also existed between the performance of the eight to nine year olds and both of the older age groups ($p<.05$). In all cases, the performance of older children was superior to that of younger children. No significant performance differences, with respect to the Null Class, occurred between learning disabled children at the six to seven and eight to nine year age levels or between those at the 10 to 11 and 12 to 13 year age levels.

The Duality Principle

As mentioned in the preceding chapter, two forms of the Duality Principle task were employed in this study. The form most often used involved an animal hierarchy, the alternative form involved a flower hierarchy. The results obtained from the two different forms were not differentiated for the purposes of this investigation.

Significant Chi Square results were obtained for all age levels compared within the population of achieving children with respect to performance on the Duality Principle task ($p<.01$). The comparisons indicated that the performance of older children was always superior to that of younger children on the Duality Principle task.

Among the age groups of learning disabled children, the performance of the six to seven year olds on the Duality Principle was inferior to that of the 10 to 11 ($p<.01$) and the 12 to 13 ($p=.001$) year olds. The performance of 12 to 13 year olds was superior to that of eight to nine year olds ($p<.05$). No significant performance differences were observed with respect to the Duality Principle task between learning disabled children at the following age levels: six to seven and eight to nine; eight to nine and 10 to 11; and 10 to 11 and 12 to 13.

In summary, relationships between stage of performance and age level were found with respect to the performance of both achieving and learning disabled children on all five classification tasks.

The relationships were not the same for achieving and learning disabled children. Within each population of children, however, whenever significant differences occurred, the performance of older children was superior to that of younger children.

Relationships Between Diagnostic Group and Stage of Development on the Piagetian Tasks

The results of the Chi Square comparisons of the numbers of achieving and learning disabled children of the same age level at the different stages of the Piagetian tasks are found in Table 6. When differences were significant, the performance of achievers was superior to that of learning disabled children.

On the Additive Composition of Classes task, the performance of achievers was superior to that of learning disabled children at only two of the four age levels: the eight to nine year age level ($p<.05$); and the 10 to 11 year age level ($p<.01$). No significant differences were detected between achieving and learning disabled children, at any of the four age levels compared, with respect to performance on the All and Some Conditions of Class Inclusion task.

The Chi Square values were significant for comparison of achieving and learning disabled children at all four age levels with respect to performance on the Singular Class task. The significant differences found for the groups were as follows: six to seven year olds ($p<.01$); eight to nine year olds ($p<.01$); 10 to 11 year olds ($p<.001$); and 12 to 13 year olds ($p=.001$).

Significant differences were detected between the performance of achieving and learning disabled children on the Null Class task

Table 6

Chi Square Comparisons of Stage Performance of Achieving and Learning Disabled Children of the Same Age Level on Five Piagetian Tasks

Task	Age Level (years)	Chi Square	df	p
Additive Composition	6- 7	3.8857	2	0.143
	8- 9	8.0234	2	0.018*
	10-11	10.2931	2	0.006**
	12-13	0.5263	1	0.468
All and Some	6- 7	4.1905	2	0.123
	8- 9	1.2526	2	0.535
	10-11	1.4063	1	0.236
	12-13	2.5000	1	0.114
Singular Class	6- 7	14.8416	3	0.002**
	8- 9	14.0260	3	0.003**
	10-11	24.3809	3	0.000***
	12-13	13.3333	2	0.001***
Null Class	6- 7	12.1600	3	0.007**
	8- 9	18.8095	3	0.001***
	10-11	11.1667	2	0.004**
	12-13	5.7846	2	0.055
Duality Principle	6- 7	2.5253	1	0.112
	8- 9	9.2904	2	0.010**
	10-11	15.6632	3	0.001***
	12-13	25.3576	3	0.000***

* $p \leq .05$

** $p \leq .01$

*** $p \leq .001$

at three of the four age levels: the six to seven year age level ($p<.01$); the eight to nine year age level ($p=.001$); and the 10 to 11 year age level ($p<.01$). With respect to the performance of achieving and learning disabled children on the Duality Principle task, the Chi Square values were significant at: the eight to nine year age level ($p=.01$); the 10 to 11 year age level ($p=.001$); and the 12 to 13 year age level ($p<.001$), but not at the six to seven year age level.

In summary, significant relationships were found between diagnostic group and stage of development on four of the classification tasks with respect to achieving and learning disabled children at the same age level. The four classification tasks were Additive Composition of Classes, Singular Class, Null Class and Duality Principle. Whenever significant differences occurred between the performance of achieving and learning disabled children of the same age level, the performance of achievers was superior to that of learning disabled children.

Evidence of Developmental Lag in Learning Disabled Children with Respect to the Acquisition of Piagetian Classification Concepts

Comparisons of the performance of achieving and learning disabled children at the same age level on the various Piagetian tasks indicated, in many instances, that stage of performance was related to diagnostic group. Whenever significant differences occurred, the performance of achievers was superior to that of learning disabled children. On the basis of these findings, it was speculated that perhaps a developmental lag occurred in the learning disabled

children with respect to the age at which they acquired the different classification concepts. It was decided, therefore, in cases where achieving and learning disabled children at the same age level differed significantly in task performance, to compare the performance of the learning disabled children with that of achievers in the next youngest age group. The Kolmogorov-Smirnov test (Marascuilo and McSweeney, 1977) was used to compare the developmental curves for stage performance of the appropriate groups of achieving and learning disabled children.

Achieving and learning disabled children at the eight to nine year age level had differed significantly with respect to performance on the Additive Composition of Classes, Singular Class, Null Class and Duality Principle tasks. The Kolmogorov-Smirnov tests indicated no significant differences between the performance of learning disabled children at the eight to nine year age level and achievers at the six to seven year age level on these tasks.

Achieving and learning disabled children at the 10 to 11 year age level had also differed significantly in performance on the Additive Composition of Classes, the Singular Class, the Null Class and the Duality Principle tasks. The Kolmogorov-Smirnov tests indicated no significant performance differences between learning disabled children at the 10 to 11 year age level and achievers at the eight to nine year age level on any of these tasks.

The performance of achieving and learning disabled children at the 12 to 13 year age level had differed significantly on the Singular Class and Duality Principle tasks. The Kolmogorov-Smirnov tests

indicated that the performance of achievers at the 10 to 11 year age level was also superior to that of the 12 to 13 year old learning disabled children on the Singular Class ($p=.05$) and Duality Principle ($p<.05$) tasks. Subsequent comparisons of the performance of 12 to 13 year old learning disabled children with that of eight to nine year old achievers indicated no significant differences between these two groups with respect to the Singular Class and Duality Principle tasks.

In summary, whenever achievers and learning disabled children at the same age level differed significantly with respect to performance on the various Piagetian tasks, the performance of the learning disabled children was compared with that of the next youngest group of achievers. The Kolmogorov-Smirnov test was used for this purpose and, generally, when the appropriate groups of achieving and learning disabled children were compared no significant differences in performance were detected. An exception to this general finding was that the performance of achievers at the 10 to 11 year age level was superior to that of 12 to 13 year old learning disabled children with respect to the Singular Class and Duality Principle tasks. There would appear to be some evidence of a developmental lag with respect to the age at which learning disabled children acquired several of the classification concepts, especially the concepts of the Singular Class and the Duality Principle.

<u>Order of Acquisition of the Piagetian Classification Concepts</u>

The stage of development for each child on each of the five classification tasks was determined. A numerical pattern representing the stage of development on each of the individual Piagetian tasks was assigned to each child. The sequence of tasks in the pattern was Additive Composition of Classes, All and Some Conditions of Class Inclusion, the Singular Class, the Null Class and the Duality Principle. For example, a child at stage 3 on Additive Composition of Classes, stage 3 on the All and Some Conditions of Class Inclusion, stage 2 on the Singular Class, stage 3 on the Null Class and stage 2 on the Duality Principle was designated by the pattern 33232.

On the basis of the patterns of task performance, the populations of achieving and learning disabled children were grouped according to the number of Piagetian tasks on which they demonstrated an operational level of performance, i.e., stage 3 or stage 4. The patterns of stage development for achieving and learning disabled children demonstrating operational performance on no, one, two, three, four and five Piagetian tasks are presented in Tables 7, 8, 9, 10, 11 and 12 respectively.

Within the groups of achieving and learning disabled children demonstrating operational level performance on one to five Piagetian tasks, the frequencies of the individual tasks and combinations of tasks on which operation level performance had been achieved were calculated (Tables 8, 9, 10, 11 and 12). This was done in order to determine whether achieving and learning disabled children

demonstrated an operational level of performance on a particular task or combination of tasks prior to others. The following results were obtained for children who were operational on no, one, two, three, four and five classification tasks.

No Tasks at Operational Level

Five achieving and 18 learning disabled children did not demonstrate operational level performance on any of the Piagetian tasks (Table 7). The level of concept development seemed to be more advanced for the achievers. Four of the five achievers as compared with eight of 18 learning disabled children were at stage 2 on three or more of the tasks.

One Task at Operational Level

Ten achieving and 23 learning disabled children demonstrated operational level performance on one Piagetian task (Table 8). Four achievers and 16 learning disabled children were operational on the All and Some Conditions of Class Inclusion, four achievers and four learning disabled children were operational on the Null Class, one achiever and three learning disabled children were operational on the Additive Composition of Classes and one achiever was operational on the Singular Class. Operational performance was demonstrated on four different tasks. Children who were operational on only one task did not demonstrate this performance on a common task.

Two Tasks at Operational Level

Seven achieving and 12 learning disabled children were operational on two Piagetian classification tasks (Table 9). Four combinations of tasks occurred. The combinations of tasks and the

Table 7

Patterns of Stage Development of Achieving and Learning Disabled Children Demonstrating Operational Performance on No Piagetian Tasks

Task and Stage					Pattern	Achievers (N)	Learning Disabled (N)	Total (N)
Additive Composition	All/Some	Singular Class	Null Class	Duality Principle				
1	1	1	1	1	11111	0	1	1
1	2	1	1	1	12111	0	3	3
1	2	1	2	1	12121	1	4	5
2	1	1	2	1	21121	0	1	1
2	2	1	1	1	22111	0	1	1
1	2	2	2	1	12221	1	0	1
2	2	1	2	1	22121	1	2	3
2	2	1	1	2	22112	0	1	1
1	2	1	2	2	12122	0	4	4
2	2	1	2	2	22122	2	1	3
Total Number of Subjects						5	18	23
Number of Patterns Found						4	9	10

Table 8

Patterns of Stage Development of Achieving and Learning Disabled Children Demonstrating Operational Performance on One Piagetian Task

Task and Stage					Pattern	Achievers (N)	Learning Disabled (N)	Total (N)
Additive Composition	All/Some	Singular Class	Null Class	Duality Principle				
1	3	1	2	1	13121	1	4	5
2	3	1	1	1	23111	0	1	1
1	2	1	3	1	12131	0	1	1
1	3	1	2	2	13122	1	3	4
3	2	1	2	1	32121	0	1	1
1	2	1	3	2	12132	0	1	1
1	2	1	4	2	12142	1	0	1
2	3	1	2	2	23122	2	7	9
3	2	1	2	2	32122	0	2	2
2	2	1	3	2	22132	1	2	3
1	3	2	2	2	13222	0	1	1
3	2	2	2	1	32221	1	0	1
1	2	2	3	1	12231	1	0	1
2	2	1	4	2	22142	1	0	1
2	2	3	2	2	22322	1	0	1
Total Number of Subjects						10	23	33
Number of Patterns Found						9	10	15
Frequencies of task on which operational performance is demonstrated:								
All/Some						4	16	20
Null Class						4	4	8
Additive Composition						1	3	4
Singular Class						1	0	1
Duality Principle						0	0	0

numbers of children demonstrating operational performance on each of them were as follows: (1) Additive Composition of Classes and Null Class, one achiever and eight learning disabled; (2) All and Some Conditions of Class Inclusion and Null Class, four achievers and four learning disabled; (3) Additive Composition of Classes and All and Some Conditions of Class Inclusion, one achiever and one learning disabled; and (4) Singular Class and Null Class, one achiever and one learning disabled child.

With respect to individual task performance by achieving and learning disabled children who were operational on two Piagetian tasks: six achievers and 13 learning disabled were operational on the Null Class; two achievers and nine learning disabled were operational on the Additive Composition of Classes; five achievers and five learning disabled were operational on the All and Some Conditions of Class Inclusion; one achiever and one learning disabled child were operational on the Singular Class.

Three Tasks at Operational Level

Operational level performance was demonstrated on three Piagetian tasks by 12 achieving and 10 learning disabled children (Table 10). The four combinations of tasks which occurred and the numbers of children demonstrating the combinations were: (1) Additive Composition of Classes, All and Some Conditions of Class Inclusion and Null Class, five achievers and seven learning disabled; (2) Additive Composition of Classes, Singular Class and Null Class, five achievers and one learning disabled; (3) All and Some Conditions of Class Inclusion, Singular Class and Null Class, two

Table 9

Patterns of Stage Development of Achieving and Learning Disabled Children Demonstrating Operational Performance on Two Piagetian Tasks

Task and Stage					Pattern	Achievers (N)	Learning Disabled (N)	Total (N)
Additive Composition	All/Some	Singular Class	Null Class	Duality Principle				
1	3	1	3	1	13131	0	1	1
2	3	1	3	1	23131	0	1	1
3	3	1	2	2	33122	1	1	2
2	3	1	3	2	23132	1	2	3
3	2	1	3	2	32132	0	3	3
3	2	1	4	2	32142	1	3	4
3	2	2	4	1	32241	0	1	1
3	2	2	3	2	32232	0	1	1
2	2	3	3	2	22332	0	1	1
2	3	2	3	2	23232	1	0	1
2	3	2	4	2	23242	2	0	2
2	2	3	4	2	22342	1	0	1
Total Number of Subjects						7	14	21
Number of Patterns Found						6	9	12
Frequencies of combinations of tasks on which operational performance is demonstrated:								
Additive Composition and Null Class						1	8	9
All/Some and Null Class						4	4	8
Additive Composition and All/Some						1	1	2
Singular Class and Null Class						1	1	2
Frequencies of individual tasks on which operational performance is demonstrated:								
Null Class						6	13	19
Additive Composition						2	9	11
All/Some						5	5	10
Singular Class						1	1	2
Duality Principle						0	0	0

Table 10

Patterns of Stage Development of Achieving and Learning Disabled Children Demonstrating Operational Performance on Three Piagetian Tasks

Task and Stage					Pattern	Achievers (N)	Learning Disabled (N)	Total (N)
Additive Composition	All/Some	Singular Class	Null Class	Duality Principle				
3	3	1	3	2	33132	1	1	2
2	3	3	4	1	23341	1	0	1
3	3	1	4	2	33142	0	2	2
1	3	3	4	2	13342	1	1	2
3	3	3	2	2	33322	0	1	1
3	3	2	3	2	33232	3	3	6
3	2	3	4	2	32342	5	1	6
2	3	2	4	2	33242	1	1	2
Total Number of Subjects						12	10	22
Number of Patterns Found						6	7	8
Frequencies of combinations of tasks on which operational performance is demonstrated:								
Additive Composition, All/Some and Null Class						5	7	12
Additive Composition, Singular Class and Null Class						5	1	6
All/Some, Singular Class and Null Class						2	1	3
Additive Composition, All/Some and Singular Class						0	1	1
Frequencies of individual tasks on which operational performance is demonstrated:								
Null Class						12	9	21
Additive Composition						10	9	19
All/Some						7	9	16
Singular Class						7	3	10
Duality Principle						0	0	0

achievers and one learning disabled; and (4) Additive Composition of Classes, All and Some Conditions of Class Inclusion and Singular Class, one learning disabled child.

Within the group of children demonstrating operational performance on three Piagetian tasks, 12 achievers and nine learning disabled were operational on the Null Class; 10 achievers and nine learning disabled were operational on the Additive Composition of Classes; seven achievers and nine learning disabled were operational on the All and Some Conditions of Class Inclusion; and seven achievers and three learning disabled demonstrated operational level performance on the Singular Class.

Four Tasks at Operational Level

Thirteen achieving and 11 learning disabled children were operational on four Piagetian tasks (Table 11). Five combinations of tasks occurred. The combinations of tasks and numbers of achieving and learning disabled children demonstrating each combination were as follows: (1) Additive Composition of Classes, All and Some Conditions of Class Inclusion, Singular Class and Null Class, eight achievers and six learning disabled; (2) Additive Composition of Classes, All and Some Conditions of Class Inclusion, Null Class and Duality Principle, three achievers and four learning disabled; (3) Additive Composition of Classes, All and Some Conditions of Class Inclusion, Singular Class and Duality Principle, one learning disabled child; (4) Additive Composition of Classes, Singular Class, Null Class and Duality Principle, one achiever; and (5) All and Some Conditions of Class Inclusion, Singular Class, Null Class and

Table 11

Patterns of Stage Development of Achieving and Learning Disabled Children
Demonstrating Operational Performance on Four Piagetian Tasks

Task and Stage					Pattern	Achievers (N)	Learning Disabled (N)	Total (N)
Additive Composition	All/Some	Singular Class	Null Class	Duality Principle				
3	3	1	3	3	33133	1	0	1
3	3	3	2	3	33323	0	1	1
3	3	2	3	3	33233	1	1	2
3	3	3	3	2	33332	4	2	6
2	3	3	3	3	23333	1	0	1
3	3	3	4	2	33342	4	4	8
3	3	2	4	3	33243	1	3	4
3	2	3	4	3	32343	1	0	1
Total Number of Subjects						13	11	24
Number of Patterns Found						7	5	8
Frequencies of combinations of tasks on which operational performance is demonstrated:								
Additive Composition, All/Some, Singular Class and Null Class						8	6	14
Additive Composition, All/Some, Null Class and Duality Principle						3	4	7
Additive Composition, All/Some, Singular Class and Duality Principle						0	1	1
Additive Composition, Singular Class, Null Class and Duality Principle						1	1	1
All/Some, Singular Class, Null Class and Duality Principle						1	0	1
Frequencies of individual tasks on which operational performance is demonstrated:								
Additive Composition						12	11	23
All/Some						12	11	23
Null Class						13	10	23
Singular Class						10	7	17
Duality Principle						5	5	10

Duality Principle, one achiever.

Within the group of subjects demonstrating operational performance on four Piagetian tasks, 12 achievers and 11 learning disabled were operational on the Additive Composition of Classes, 12 achievers and 11 learning disabled were operational on All and Some Conditions of Class Inclusion, 13 achievers and 10 learning disabled were operational on the Null Class, 10 achievers and seven learning disabled were operational on the Singular Class, and five achievers and five learning disabled children were operational on the Duality Principle. Operational performance was not demonstrated on the Duality Principle until children were operational on at least three of other four Piagetian tasks.

Five Tasks at Operational Level

Thirty-three achieving and four learning disabled children demonstrated an operational level of performance on all of the Piagetian classification tasks (Table 12). Forty-one percent of the total population of achievers attained an operational level of performance on all of the classification tasks. Only five percent of the total population of learning disabled children attained a similar status.

The Order of Task Difficulty

Within the populations of achieving and learning disabled children, the numbers of children operational on each of the classification tasks were as follows:

Table 12

Patterns of Stage Development of Achieving and Learning Disabled Children Demonstrating Operational Performance on Five Piagetian Tasks

Task and Stage					Pattern	Achievers (N)	Learning Disabled (N)	Total (N)
Additive Composition	All/Some	Singular Class	Null Class	Duality Principle				
3	3	3	3	3	33333	2	1	3
3	3	3	4	3	33343	14	2	16
3	3	3	3	4	33334	3	0	3
3	3	3	4	4	33344	14	1	15
Total Number of Subjects						33	4	37
Number of Patterns Found						4	3	4
Frequencies of combination of tasks on which operational performance is demonstrated:								
Additive Composition, All/Some, Singular Class, Null Class and Duality Principle						33	4	37
Frequencies of individual tasks on which operational performance is demonstrated:								
Additive Composition						33	4	37
All/Some						33	4	37
Null Class						33	4	37
Singular Class						33	4	37
Duality Principle						33	4	37

	Achievers	Learning Disabled
Null Class	68	40
All and Some	61	45
Additive Composition	58	36
Singular Class	52	15
Duality Principle	38	9

The numbers of children who are operational on the various tasks might serve as a very general index of the order of difficulty of the tasks. With the exception that the positions of the Null Class and All and Some Conditions of Class Inclusion are reversed for achieving and learning disabled children, the order of difficulty is the same.

The Results of the Analysis of the Levels of Processing Memory Task Data and the Examination of the Interview Data

The recall responses given on the levels of processing task by achieving and learning disabled children at four age levels were subjected to statistical analysis in order to determine whether there was evidence of: (1) developmental trends with respect to the memory ability of achieving and learning disabled children, as indicated by their total recall performance on the levels of processing task; (2) differences in the total recall performance of achieving and learning disabled children at the same age level; and (3) support for the Craik and Lockhart (1972) position that on a test of recall for words processed at physical, phonemic and semantic levels, the hierarchy of recall will be semantic > phonemic > physical. The interview data were examined for evidence that

achieving and learning disabled children: (1) had spontaneously used category labels for the recall of information; and (2) could effectively use cues, provided in the form of category labels, to recall information beyond that reported on the spontaneous recall test.

The Analysis of the Recall Results on the Levels of Processing Task

The scores for words recalled at each of the three levels of processing and the total recall score on the memory task were determined for each subject. The mean scores and standard deviations obtained by the groups of achieving and learning disabled children at the four different age levels for physical, phonemic, and semantic level words and for total recall are presented in Table 13.

Memory Development in Achieving and Learning Disabled Children

The total recall scores obtained on the levels of processing task by achieving and learning disabled children at four different age levels were subjected to a two-way analysis of variance, 2 (groups) x 4 (age levels). Results of this analysis indicated: a significant main effect for groups, $F\ (1,152) = 77.22$, $p<.001$; a significant main effect for age levels, $F\ (3,152) = 49.18$, $p<.001$; and a significant interaction between groups and age levels, $F\ (3,152) = 2.67$, $p<.05$. The means involved in this interaction are graphed in Figure 7. The mean total recall scores for achieving and learning disabled children at each of the four different age levels were as follows: six to seven years, achievers 7.35, learning disabled 5.05; eight to nine years, achievers 8.85, learning disabled 7.20; 10 to 11 years, achievers 12.05, learning

Table 13

Recall Means and Standard Deviations for Achieving and Learning Disabled Children at Four Age Levels - Levels of Processing Task

Source	Age Level (years)	Achievers		Learning Disabled	
		$\bar{X}$	s.d.	$\bar{X}$	s.d.
Physical Processing	6 - 7	2.00	1.12	1.55	0.99
	8 - 9	2.40	1.19	2.05	1.32
	10 - 11	3.15	1.50	2.45	0.89
	12 - 13	3.40	1.14	2.50	1.32
Phonemic Processing	6 - 7	1.70	1.03	1.15	0.88
	8 - 9	2.10	1.21	1.35	0.99
	10 - 11	3.05	1.61	1.55	1.23
	12 - 13	2.50	1.10	2.25	1.16
Semantic Processing	6 - 7	3.65	1.63	2.35	1.27
	8 - 9	4.35	1.63	3.80	1.67
	10 - 11	5.85	1.76	4.05	1.61
	12 - 13	6.40	1.31	4.85	1.50
Total Recall	6 - 7	7.35	2.13	5.05	1.05
	8 - 9	8.85	1.23	7.20	2.31
	10 - 11	12.05	1.61	8.05	1.91
	12 - 13	12.30	2.20	9.60	2.41

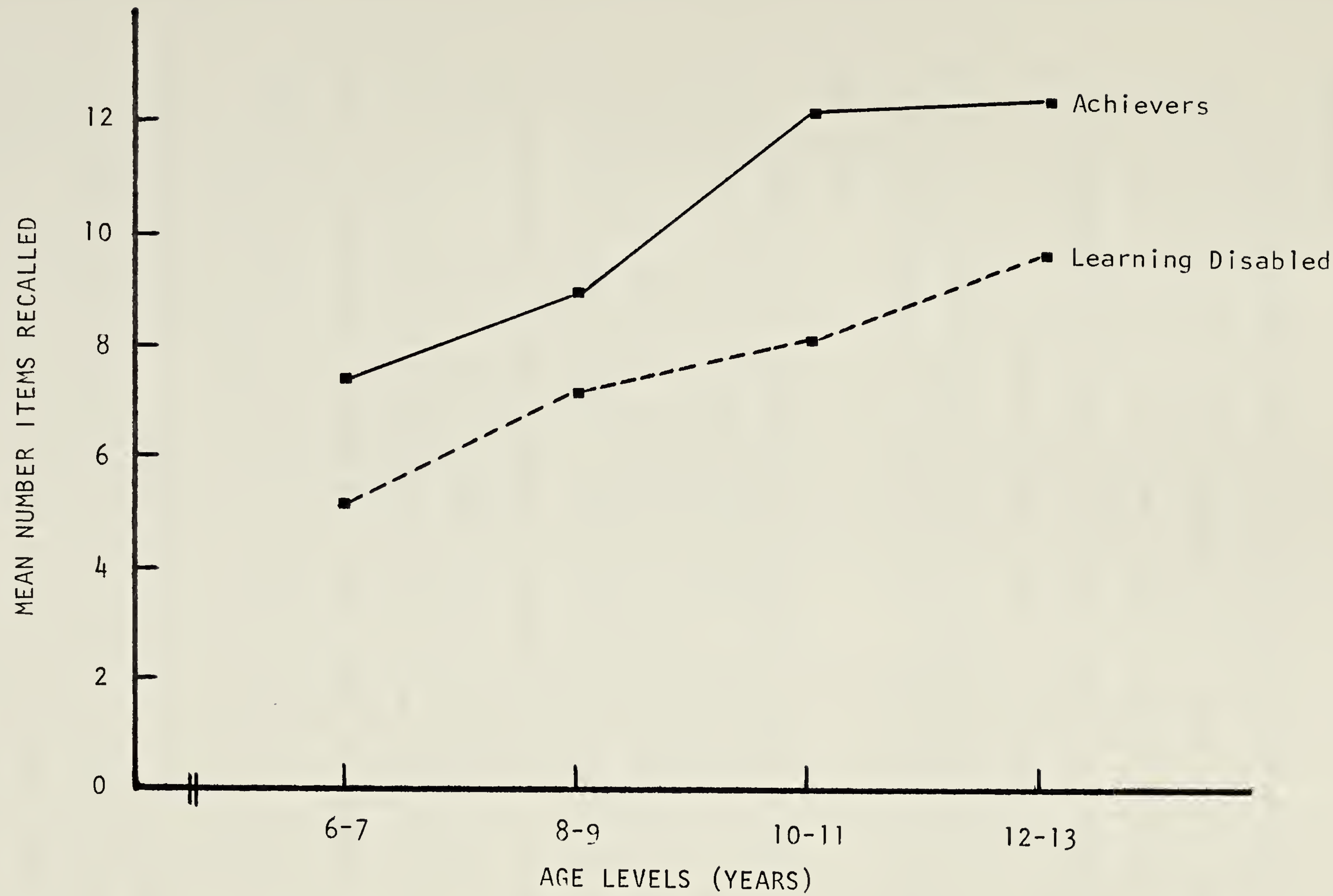

FIGURE 7. Total recall responses for achieving and learning disabled children at four different age levels.

disabled 8.05; and 12 to 13 years, achievers 12.30, learning disabled 9.60.

Multiple comparisons of all the unconfounded means, i.e., means in the same row or column, graphed in Figure 7 were made using the Tukey (a) procedure. This was done to seek information regarding: (1) developmental trends in the recall ability of both achieving and learning disabled children; and (2) differences in the recall ability of achieving and learning disabled children at the same age level. The results of the Tukey (a) tests are summarized in Table 14.

Comparison of the mean total recall scores of achieving children at the four different age levels indicated: (1) the recall of achievers at the six to seven and eight to nine year age levels did not differ significantly; (2) the recall of both the six to seven and eight to nine year olds was inferior ($p<.01$) to that of both the 10 to 11 and 12 to 13 year olds; and (3) the recall of the 10 to 11 and 12 to 13 year olds did not differ significantly. In general, the recall of children older than 10 years of age was superior to that of children younger than 10 years of age.

Within the population of learning disabled children, the Tukey (a) tests indicated: (1) the total recall of the youngest group of children was inferior ($p<.01$) to that of each of the three older groups; (2) the recall of the eight to nine year olds was inferior ($p<.01$) to that of the 12 to 13 year olds; (3) the recall of the eight to nine and 10 to 11 year olds did not differ significantly; and (4) the recall of the 10 to 11 and 12 to 13 year olds did not

Table 14

Tukey (a) Tests of Unconfounded Means Involved in Groups x Age Levels Interaction for Total Recall by Achieving and Learning Disabled Children at Four Age Levels

Group(s)	Age Level(s) Compared (years)	Difference of Means	p*
Achievers and Learning Disabled	6- 7	2.30	<.01
	8- 9	1.65	>.05
	10-11	4.00	<.01
	12-13	2.70	<.01
Achievers	6- 7 and 8- 9	1.50	>.05
	6- 7 and 10-11	4.70	<.01
	6- 7 and 12-13	4.95	<.01
	8- 9 and 10-11	3.20	<.01
	8- 9 and 12-13	3.45	<.01
	10-11 and 12-13	0.25	>.05
Learning Disabled	6- 7 and 8- 9	2.15	<.01
	6- 7 and 10-11	3.00	<.01
	6- 7 and 12-13	4.55	<.01
	8- 9 and 10-11	0.85	>.05
	8- 9 and 12-13	2.40	<.01
	10-11 and 12-13	1.55	>.05

*Critical value at .01 level = 2.034 and at .05 level = 1.726

differ significantly. In general, not until learning disabled children were 12 to 13 years of age was their recall superior to that of children at both the six to seven and eight to nine year age levels.

The mean total recall scores obtained by achieving and learning disabled chidren at the same age level were compared using the Tukey (a) tests (Table 14). The results of these comparisons indicated that the recall of achievers was superior to that of learning disabled children at the six to seven ($p<.01$), 10 to 11 ($p<.01$), and 12 to 13 ($p<.01$) year age level but not at the eight to nine year age level.

Since the total recall of achievers was superior to that of learning disabled children at the two oldest age levels, it was decided to compare the recall of the learning disabled children with that of achievers in the next youngest age group. The appropriate pairs of total recall means were compared using the Tukey (a) procedure for the comparison of confounded means, i.e., means not in the same row or column. The following results were obtained: (1) the total recall of 10 to 11 year old learning disabled children ($\bar{X}$ = 8.05) did not differ significantly from that of eight to nine year old achievers ($\bar{X}$ = 8.85); and (2) the total recall of 12 to 13 year old learning disabled children ($\bar{X}$ = 9.60) was inferior ($p<.01$) to that of 10 to 11 year old achievers ($\bar{X}$ = 12.05), but not to that of eight to nine year old achievers ($\bar{X}$ = 8.85).

In summary, memory appeared to be developmental in both the

achieving and learning disabled children. The recall of achievers older than 10 years of age was superior to that of achievers younger than 10 years of age. Not until learning disabled children were 12 to 13 years of age was their recall superior to that of children at both the six to seven and eight to nine year age levels.

The recall of achieving children was superior to that of learning disabled children at all age levels except the eight to nine year level. The recall ability of 10 to 11 and 12 to 13 year old learning disabled children appeared to lag two and four years, respectively, behind that of their achieving chronological age peers.

The Recall of Words Processed at Physical, Phonemic, and Semantic Levels

The scores obtained by achieving and learning disabled children for the three levels of processing were subjected to a three-way analysis of variance, 2 (groups) x 4 (age levels) x 3 (levels of processing), the levels factor repeated within. This was done in order to determine whether the present study would provide support for the Craik and Lockhart (1972) position that the hierarchy of recall for words processed at physical, phonemic and semantic levels will be semantic > phonemic > physical. The results of the analysis of variance are summarized in Table 15.

The three-way analysis of variance indicated significant main effects for groups ($p<.001$) and age levels ($p<.001$) and also a significant groups x age levels interaction ($p<.05$). These results

Table 15

ANOVA for Recall Data Involving 2 (Groups) X 4 (Age Levels) X 3 (Levels of Processing)
(N = 160)

Source	df	SS	MS	F	P
Subjects	159	471.00			
Between Variables					
B_1 Diagnostic Group (Learning Disabled, Achievers)	1	94.52	94.52	77.2204	0.000
B_2 Age Levels	3	180.61	60.20	49.1842	0.000
B_{12} Interaction: Diagnostic Group X Age Levels	3	9.82	3.27	2.6751	0.049
EB_{12}	152	186.05	1.22		
Within Variables					
W_1 Levels of Processing	2	542.15	271.08	136.1206	0.000
W_1B_1 Interaction: Levels X Diagnostic Group	2	10.74	5.37	2.6959	0.069
W_1B_2 Interaction: Levels X Age Levels	6	34.41	5.74	2.8800	0.009
W_1B_{12} Interaction: Levels X Diagnostic Group X Age Levels	6	9.30	1.55	0.7780	0.587
EW_1B_{12}	304	605.40	1.99		
W	320	1202.00			

were based upon the scores obtained by children when their scores for the three levels of processing were averaged together. These results will not be discussed in any detail here since groups and age levels main effects and the interaction between groups and age levels have already been presented and discussed in terms of the total recall scores obtained by achieving and learning disabled children.

The three-way analysis of variance summarized in Table 15 indicated a significant main effect for levels of processing ($p<.001$) and also a significant interaction between levels of processing and age levels ($p<.01$). The levels of processing x diagnostic groups and the levels of processing x diagnostic groups x age levels interactions were not significant at the .05 level.

The mean physical, phonemic and semantic recall of children at the four age levels (data collapsed over diagnostic groups) is presented graphically in Figure 8. Multiple comparisons of the unconfounded means graphed in Figure 8 were made using the Tukey (a) tests. Six to seven year olds recalled fewer physical level words than the 10 to 11 ($p<.05$) and the 12 to 13 ($p<.01$) year olds but not the eight to nine year olds. No significant differences with respect to the recall of phonemic level words were detected between any of the age levels. Six to seven year olds recalled fewer semantic level words than the eight to nine ($p<.05$), 10 to 11 ($p<.01$), and 12 to 13 ($p<.01$) year age groups. Eight to nine year old children recalled significantly fewer semantic level words than the 12 to 13 ($p<.01$) year olds. The recall of the eight to nine

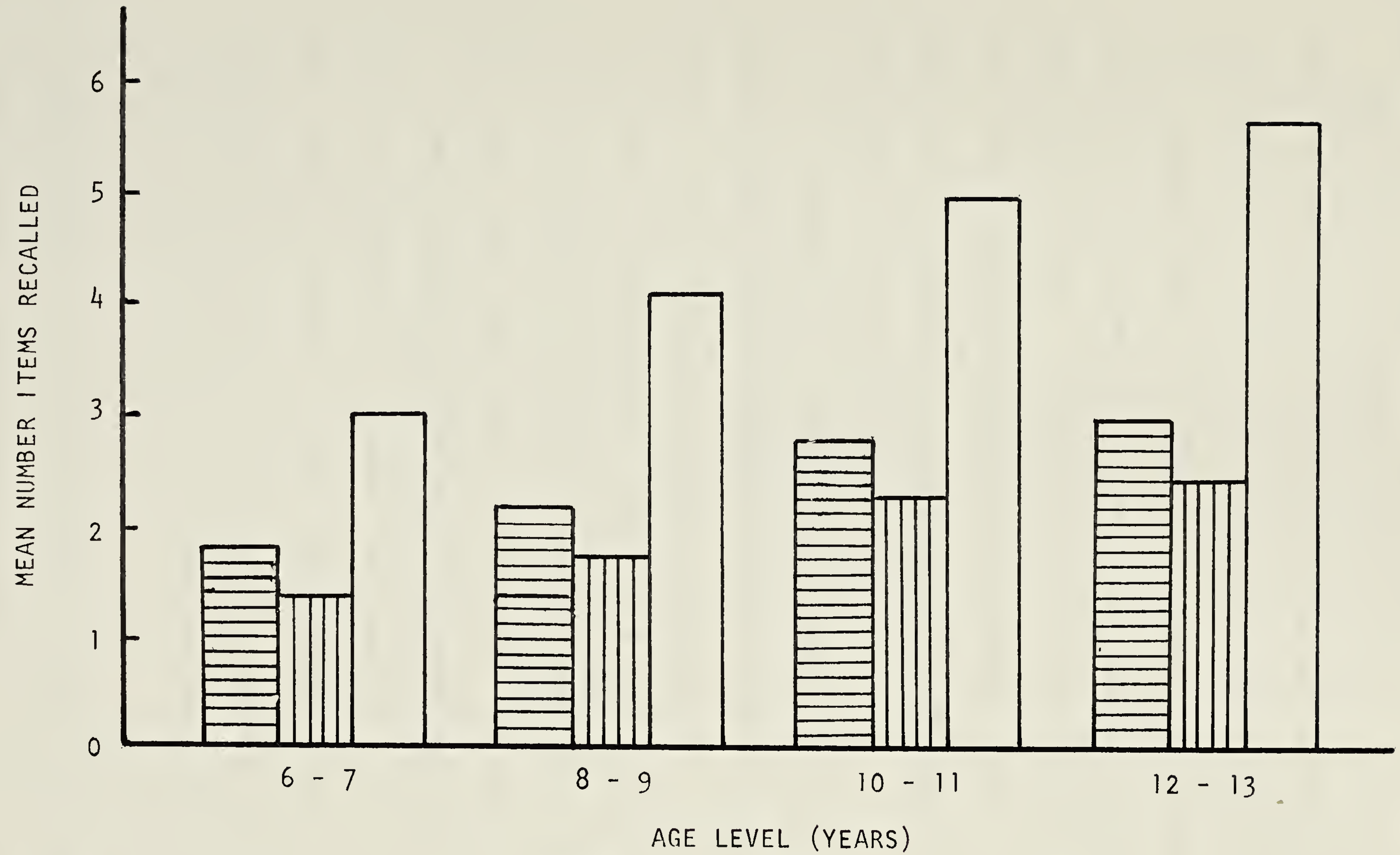

FIGURE 8. The mean physical, phonemic and semantic recall of children at four age levels collapsed over groups.

and 10 to 11 year olds did not differ with respect to semantic words, nor did that of the 10 to 11 and 12 to 13 year olds.

The results of Tukey (a) tests of the means for the three levels of processing within each of the four different age groups are summarized in Table 16. At all age levels significant differences existed between the recall of semantic and physical level words ($p<.01$) and between the recall of semantic and phonemic level words ($p<.01$). Children recalled more words at the semantic level than at either the physical or phonemic level. There were no significant differences at any age level with respect to the recall of phonemic and physical level words.

The mean physical, phonemic, and semantic recall scores of achieving and learning disabled children (data collapsed over age levels) were as follows: physical, achievers $\bar{X} = 2.74$, learning disabled $\bar{X} = 2.13$; phonemic, achievers $\bar{X} = 2.34$, learning disabled $\bar{X} = 1.58$; semantic, achievers $\bar{X} = 5.06$, learning disabled $\bar{X} = 3.76$. These means have been graphed in Figure 9. Multiple comparisons of the means using Tukey (a) tests indicated that as a group achievers recalled more phonemic and semantic level words ($p<.01$) than learning disabled children. No differences were found between the groups with respect to the recall of physical words. Within the separate populations of achieving and learning disabled children, the recall of semantic level words was superior to the recall of both physical ($p<.01$) and phonemic ($p<.01$) level words. No differences were found between the recall of physical and phonemic level words.

Table 16

Tukey (a) Tests of Unconfounded Means Involved in Levels x Age Interaction: Summary for Individual Age Groups

Age Level (years)	Levels Compared	Difference of Means	p*
6 - 7	Semantic and Physical	1.225	<.01
	Phonemic and Physical	0.350	>.05
	Semantic and Phonemic	1.575	<.01
8 - 9	Semantic and Physical	1.850	<.01
	Phonemic and Physical	0.500	>.05
	Semantic and Phonemic	2.350	<.01
10-11	Semantic and Physical	2.150	<.01
	Phonemic and Physical	0.500	>.05
	Semantic and Phonemic	2.650	<.01
12-13	Semantic and Physical	2.675	<.01
	Phonemic and Physical	0.575	>.05
	Semantic and Phonemic	3.250	<.01

* Critical value at .05 level = 0.957 and at .01 level = 1.113

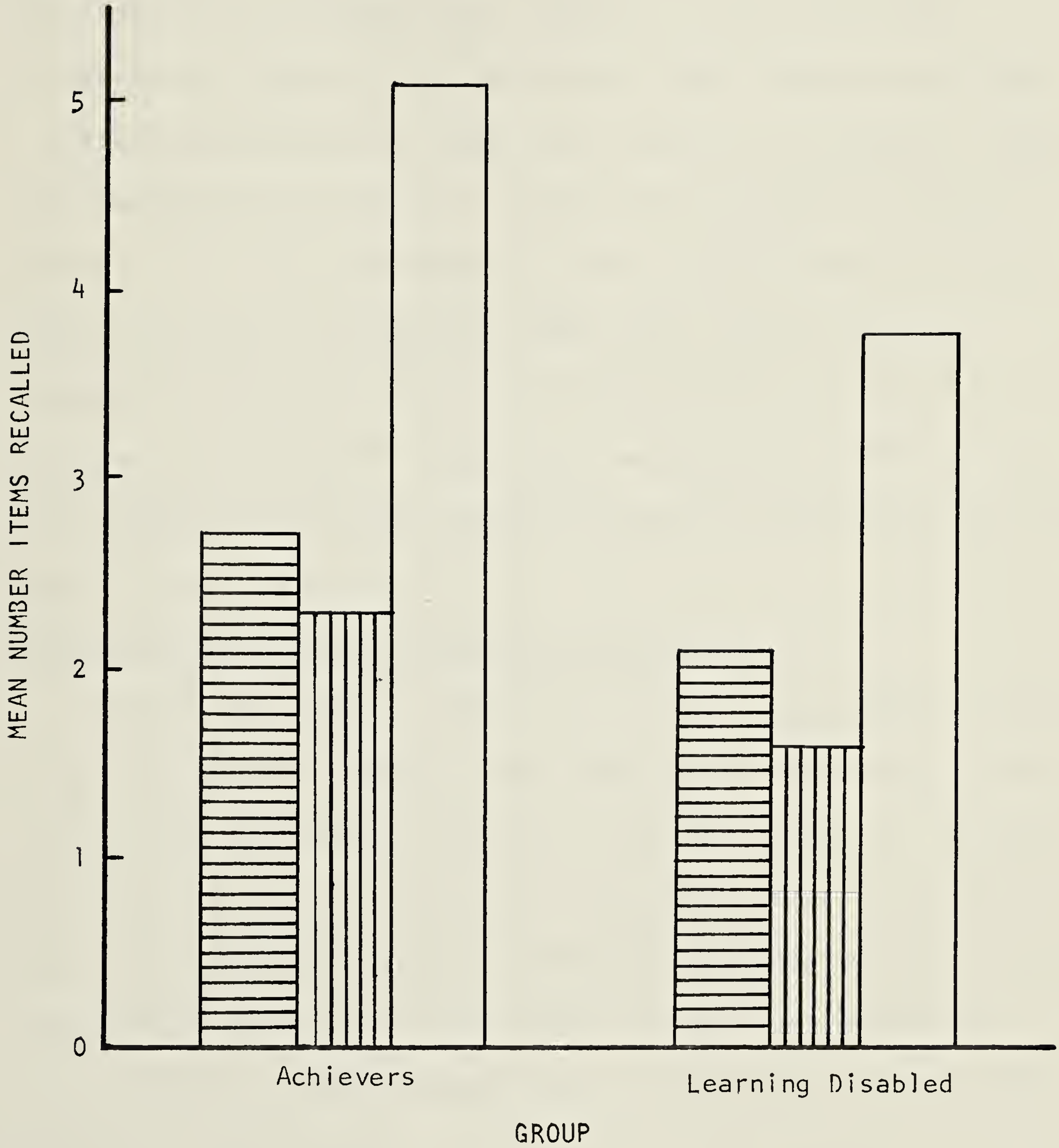

FIGURE 9. The mean physical , phonemic and semantic recall of achieving and learning disabled children collapsed over age levels.

In summary, the results obtained for the recall of physical, phonemic, and semantic level words by: (1) children at different age levels (data collapsed over diagnostic groups); and (2) achieving and learning disabled children (data collapsed over age levels) indicated partial support for the Craik and Lockhart (1972) position that the hierarchy of recall will be semantic > phonemic > physical. The recall of semantic level words was superior to the recall of phonemic and physical level words but the recall of phonemic and physical level words did not differ. It was also observed that the recall of achievers was superior to that of learning disabled children with respect to semantic and phonemic but not physical level words.

The Results of the Analysis of the Interview Data

If children mentioned remembering certain words reported on the recall test because they belonged to particular categories of items, i.e., fruit, vegetables, furniture, clothing, weapons or vehicles, the category names were recorded by the experimenter. Any categories not mentioned by the children were suggested by the experimenter and children were asked if they could remember any words belonging to those categories. A cued recall score was thus obtained for each child.

The mean numbers of categories recalled, the mean cued recall scores, and the mean spontaneous + cued recall scores were calculated for achieving and learning disabled children at the four different age levels. This information is summarized in Table 17.

Table 17

The Effect of Cueing on the Recall Performance of Achieving and Learning Disabled Children at Four Age Levels

Age Level (years)	Spontaneous Recall ($\bar{X}$)		Categories Recalled ($\bar{X}$)		Cued Recall ($\bar{X}$)		Spontaneous + Cued Recall ($\bar{X}$)	
	Achievers	Learning Disabled	Achievers	Learning Disabled	Achievers	Learning Disabled	Achievers	Learning Disabled
6 - 7	7.35	5.05	1.10	0.40	4.40	5.45	11.75	10.50
8 - 9	8.85	7.20	2.80	1.20	4.45	5.05	13.30	12.25
10 - 11	12.05	8.05	4.10	2.00	2.15	4.50	14.20	12.55
12 - 13	12.30	9.60	4.00	2.45	2.15	3.90	14.45	13.50

The interview data was not subjected to any statistical analysis beyond the calculation of the means presented in Table 17 and a descriptive analysis of the interview data, based upon the examination of these means, follows.

The mean numbers of categories recalled by achieving and learning disabled children at the four different age levels were as follows: six to seven year, achievers 1.10, learning disabled 0.40; eight to nine years, achievers 2.80, learning disabled 1.20; 10 to 11 years, achievers 4.10, learning disabled 2.00; and 12 to 13 years, achievers 4.00, learning disabled 2.45. At each age level, achievers reported the use of more categories for recall of information than learning disabled children. This result was not unexpected since the spontaneous free recall of achievers on the levels of processing task was superior to that of learning disabled children at the same age level ($p<.01$).

Older achieving children reported using more category labels for recall of information than did younger achievers. This was also true with respect to the older and younger learning disabled children. These results also were not unexpected since within the populations of both achieving and learning disabled children the free recall of older children was superior to that of younger children.

As mentioned previously, any categories not mentioned by the children were suggested by the experimenter and a cued recall score thus obtained for each child. The cued recall means for achieving and learning disabled children at the four different age levels

were as follows: six to seven years, achievers 4.40, learning disabled 5.45: eight to nine years, achievers 4.45, learning disabled 5.05: 10 to 11 years, achievers 2.15, learning disabled 4.50; and 12 to 13 years, achievers 2.15, learning disabled 3.90. Inspection of the cued recall means indicates that both achieving and learning disabled children at all age levels were able to use cues, provided in the form of category labels, to recall information beyond that reported on the spontaneous recall test.

The cued recall means of learning disabled children were higher than those of achieving children at the same age level. The means scores for both free recall and categories recalled (Table 17) had been lower, however, for learning disabled children than for achievers at the same age level and consequently the learning disabled children had been provided with more category cues for the recall of information.

Within the populations of both achieving and learning disabled children, the cued recall means of children at younger age levels were higher than those of children at older age levels. Children at the younger age levels had recalled fewer categories (Table 17) than those at older age levels and were supplied with more cues for the recall of information.

The differences between the spontaneous recall means for achieving and learning disabled children at four age levels, i.e., six to seven, eight to nine, 10 to 11 and 12 to 13 years, given in Table 17 were 2.30, 1.65, 4.00, and 2.70, respectively. The differences between the spontaneous + cued recall means for achieving

and learning disabled children at four age levels, i.e., six to seven, eight to nine, 10 to 11 and 12 to 13 years, given in Table 17 were 1.25, 1.05, 1.65 and 0.85 respectively. The provision of cues, in the form of category labels, reduced the differences in overall recall between achieving and learning disabled children at the same age level.

<u>The Results of the Analysis of Data Relevant to the Relationship Between the Development of the Classification Concepts and Recall on the Memory Task</u>

The mean total recall scores and the mean scores for the recall of physical, phonemic and semantic words for the groups of achieving and learning disabled children at each developmental stage of each of the five classification tasks were calculated. In addition, the mean age and mean verbal IQ, as indicated by PPVT scores, were also calculated for each of these groups. This information is summarized in Table 18.

The memory ability of the children will be considered in this section only in terms of total recall. Inspection of the means presented in Table 18 indicated that generally as the stage of development of each of the Piagetian tasks increased, the mean total recall scores of both achieving and learning disabled children also increased. For example, the mean total recall scores of achievers at stage 1, 2 and 3 on the Additive Composition of Classes task were 6.86, 8.90 and 11.14, respectively. The mean total recall scores of learning disabled children at stages 1, 2 and 3 on the Additive Composition of Classes task were 5.46, 7.65

Table 18

Age, IQ and Recall Scores of Achieving and Learning Disabled Children at Different Stages of Five Piagetian Tasks

Task	Stage	Group	N	Age (months) ($\bar{X}$)	PPVT ($\bar{X}$)	Recall: Physical ($\bar{X}$)	Recall: Phonemic ($\bar{X}$)	Recall: Semantic ($\bar{X}$)	Recall: Total ($\bar{X}$)
Additive Composition	1	Achievers	7	83.42	107.57	1.57	1.14	4.14	6.86
		Learning Disabled	24	94.79	101.67	1.46	1.25	2.75	5.46
	2	Achievers	15	92.31	105.31	2.31	2.00	3.69	8.00
		Learning Disabled	20	108.95	101.65	2.30	1.60	3.75	7.65
	3	Achievers	58	127.58	111.77	3.00	2.58	5.56	11.14**
		Learning Disabled	36	133.11	104.31	2.50	1.78	4.44	8.72
All and Some Conditions of Classs Inclusion	1	Achievers	0	—	—	—	—	—	—
		Learning Disabled	2	90.50	95.00	1.50	0.00	2.00	3.50
	2	Achievers	19	98.58	106.05	2.26	1.95	4.11	8.32*
		Learning Disabled	33	103.75	103.82	1.72	1.48	3.52	6.73
	3	Achievers	61	122.30	111.38	2.89	2.46	5.36	10.70**
		Learning Disabled	45	125.36	102.49	2.46	1.71	4.02	8.20
Singular Class	1a	Achievers	4	76.50	104.25	1.75	1.50	3.75	7.00
		Learning Disabled	25	94.24	102.08	1.68	1.20	2.76	5.64
	1b	Achievers	12	93.58	107.91	2.33	1.58	4.08	8.00
		Learning Disabled	29	113.24	104.58	2.17	1.52	4.10	7.79
	2	Achievers	12	98.92	108.33	2.75	2.00	4.17	8.92
		Learning Disabled	11	137.28	101.19	2.73	1.91	4.00	8.63
	3	Achievers	52	129.17	111.48	2.90	2.65	5.60	11.15*
		Learning Disabled	15	139.73	102.00	2.40	2.07	4.60	9.07

** $p < .01$

* $p < .05$

Table 18 (Continued)

Age, IQ and Recall Scores of Achieving and Learning Disabled Children at Different Stages of Five Piagetian Tasks

Task	Stage	Group	N	Age (months) ($\bar{X}$)	PPVT ($\bar{X}$)	Recall: Physical ($\bar{X}$)	Recall: Phonemic ($\bar{X}$)	Recall: Semantic ($\bar{X}$)	Recall: Total ($\bar{X}$)
Null Class	1	Achievers	0	—	—	—	—	—	—
		Learning Disabled	7	84.71	95.86	1.86	1.43	1.86	5.14
	2	Achievers	12	81.92	106.17	2.33	1.58	3.67	7.58
		Learning Disabled	33	102.06	104.42	1.73	1.55	3.36	6.64
	3	Achievers	20	113.50	113.50	2.40	1.95	4.80	9.15
		Learning Disabled	21	127.10	103.05	2.52	1.76	4.43	8.71
	4a	Achievers	48	126.67	109.69	2.98	2.69	5.52	11.19*
		Learning Disabled	19	137.68	102.47	2.53	1.47	4.42	8.42
Duality Principle	1	Achievers	6	78.83	104.33	2.50	1.00	4.00	7.50
		Learning Disabled	22	95.09	103.73	1.59	1.32	2.45	5.36
	2	Achievers	36	98.92	109.61	2.25	2.19	4.00	8.44
		Learning Disabled	49	119.41	102.41	2.14	1.61	4.18	7.94
	3	Achievers	21	132.19	111.52	3.05	3.14	6.05	12.24**
		Learning Disabled	8	143.88	103.00	3.38	2.13	4.63	10.13
	4	Achievers	17	148.41	111.47	3.47	2.12	6.47	12.06
		Learning Disabled	1	152.00	104.00	4.00	1.00	5.00	10.00

** $p < .01$

* $p < .05$

and 8.65, respectively.

Observation of the total recall means for achievers and learning disabled children who were at the same stages of development on the same Piagetian tasks indicated that the recall of the achievers was higher. The results of t tests for significance of difference between the means of independent samples indicated that the recall of achieving children was superior to that of learning disabled children in the following instances: Additive Composition of Classes, stage 3 ($t = 4.68$, $df = 92$, $p<.01$); All and Some Conditions of Class Inclusion, stage 2 ($t = 2.59$, $df = 50$, $p=.01$) and stage 3 ($t = 4.76$, $df = 104$, $p<.001$); Singular Class, stage 3 ($t = 2.65$, $df = 65$, $p=.01$); Null Class, stage 4a ($t = 4.26$, $df = 65$, $p<.01$); and Duality Principle, stage 3 ($t = 2.43$, $df = 26$, $p<.05$). With the exception of stage 2 of the All and Some Conditions of Class Inclusion task, the differences were detected only at stages of the classification tasks at which children demonstrated operational level performance.

The highest total recall means were obtained by achieving and learning disabled children who were at stage 3 and 4 of the Duality Principle task (i.e., achievers, stage 3, $\bar{X} = 12.24$, stage 4 $\bar{X} = 12.06$; and learning disabled, stage 3, $\bar{X} = 10.13$; stage 4, $\bar{X} = 10.00$). The analysis of the Piagetian task data discussed previously suggested that the Duality Principle was the most difficult classification task for both the achieving and learning disabled children to deal with. No child demonstrated operational performance on the Duality Principle until operational performance

was demonstrated on at least three of the other four classification tasks. Some degree of generalization of classification concepts, i.e., some basic understanding of class inclusion relations, seemed essential before children could deal with the complex classifications involved in the Duality Principle.

It is speculated that relating the recall performance of the children involved in this study to their performance on individual classification tasks is not an adequate way to obtain information about the relationship between the development of classification concepts and memory ability. Rather, it is speculated that this information would be better obtained by relating memory ability to the degree of generalization of classification concepts in the children, i.e., to the number of classification concepts which the children have mastered.

For purposes of comparison, therefore, it was decided to group achieving and learning disabled children separately according to whether they were operational, i.e., at stage 3 or 4, on zero, one, two, three, four or five classification tasks. The mean age, PPVT and memory scores were calculated for these groups. The results of these calculations are summarized in Table 19. The total recall of achieving and learning disabled children demonstrating an operational level of performance on zero to five Piagetian tasks is graphed in Figure 10. A descriptive analysis of the information contained in Table 19 and Figure 10 follows.

The mean total recall scores of achieving children who were operational on zero, one, two, three, four and five classification

Table 19

Relationship between the Number of Piagetian Tasks on Which Operational Performance is Demonstrated and Age, IQ and Memory Scores in Achieving and Learning Disabled Children

	Group*	Number of Tasks on Which Operational Performance is Demonstrated											
		0 Tasks		1 Task		2 Tasks		3 Tasks		4 Tasks		5 Tasks	
		$\bar{X}$	s.d.	$\bar{X}$	s.d.	$\bar{X}$	s.d.	$\bar{X}$	s.d.	$\bar{X}$	s.d.	$\bar{X}$	s.d.
Age (months)	A	84.40	12.76	86.40	13.01	92.43	12.53	104.08	17.46	111.85	18.26	142.33	13.07
	LD	87.06	13.12	108.39	22.33	122.33	22.29	126.40	16.04	147.64	9.64	145.00	12.78
PPVT	A	103.00	7.65	105.30	9.76	105.57	12.58	112.33	5.40	114.62	8.16	111.03	8.04
	LD	102.28	11.52	102.39	8.88	104.14	9.41	105.80	10.24	99.00	4.56	106.75	12.37
Physical Level Words	A	2.20	0.45	2.10	1.20	2.14	0.69	2.58	1.51	2.46	1.27	3.30	1.40
	LD	1.44	0.86	1.87	1.10	2.71	1.14	2.20	1.14	2.36	1.03	4.00	0.82
Phonemic Level Words	A	1.80	0.84	1.30	0.95	2.14	1.07	2.08	1.16	2.85	1.46	2.67	1.38
	LD	1.11	0.96	1.70	0.97	1.57	0.85	1.30	1.25	2.45	1.64	1.25	0.50
Semantic Level Words	A	2.80	2.28	4.60	1.71	4.00	1.29	3.67	1.37	4.85	1.52	6.36	1.48
	LD	2.78	1.48	3.35	1.64	4.07	1.94	4.80	1.69	4.64	1.50	4.50	1.00
Total Recall	A	6.80	1.64	8.00	2.11	8.29	1.50	8.33	1.50	10.15	2.51	12.33	1.96
	LD	5.33	1.56	6.91	2.26	8.36	2.17	8.30	1.70	9.45	3.17	9.75	1.26
N	A	5		10		7		12		13		33	Total 80
	LD	18		23		14		10		11		4	Total 80

* A = Achievers; LD = Learning Disabled

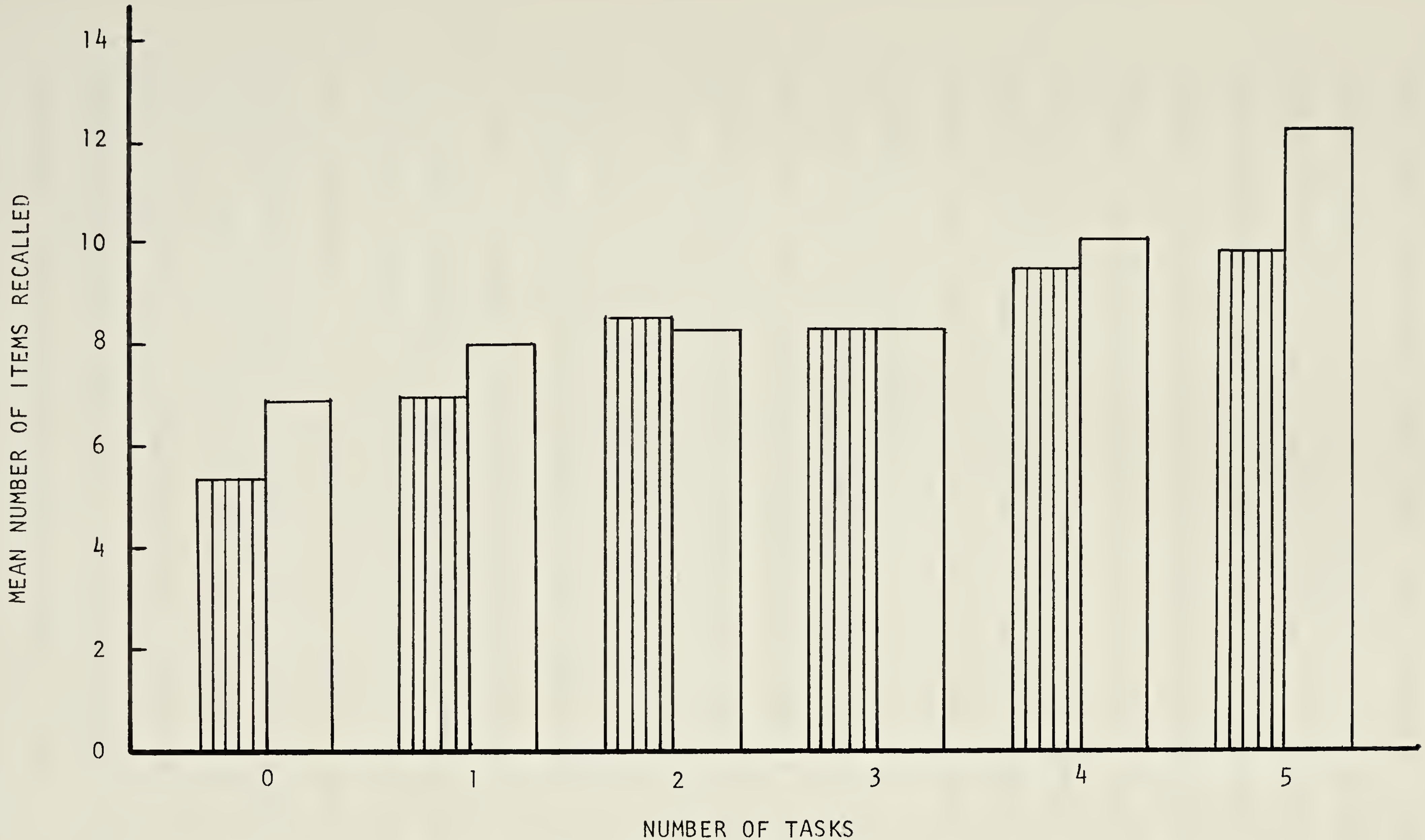

FIGURE 10. The mean total recall of achieving and learning disabled children demonstrating operational level performance on 0 to 5 Piagetian tasks.

tasks were 6.80, 8.00, 8.29, 8.33, 10.15, and 12.33, respectively. The mean total recall scores of learning disabled children who were operational on zero, one, two, three, four and five classification tasks were 5.33, 6.91, 8.36, 8.30, 9.45, and 9.75, respectively. With the exception of the groups of achieving and learning disabled who were operational on five tasks (four learning disabled and 33 achieving children were involved in this comparison), the recall of the groups of achieving and learning disabled children who were operational on the same number of classification tasks did not appear to differ greatly.

The groups of learning disabled children who were operational on one, two, three, and four classification tasks were much older than the groups of achievers who were operational on the same number of tasks (Table 19). The differences between the mean ages of the groups of learning disabled children and achievers who were operational on one, two, three, and four tasks were as follows: one task, 22 months; two tasks, 30 months; 3 tasks, 22 months; and four tasks, 36 months. There was little difference between the mean ages in months of achieving and learning disabled children who were operational on zero tasks (achievers, 84.40; learning disabled, 87.06) and on five tasks (achievers, 142.33; learning disabled, 145.00). The lack of difference between the mean ages of these groups is due to the original selection criteria which assigned subjects to discrete age levels. No child included in the study was younger than six or older than 13 years of age.

Inspection of the means in Table 19 indicates that the verbal IQ scores (PPVT) obtained by the groups of achieving and learning disabled children who were operational on zero, one, two, three, four and five classification tasks did not differ greatly except at the four task level. At the level of four tasks, the mean PPVT score of the achievers was 16 points higher than that of the learning disabled children. In all other cases, the mean PPVT scores of the groups of achievers and learning disabled children differed by less than seven points.

Inspection of the means graphed in Figure 10 indicates that within the population of achievers, progress from zero tasks at the operational level to one task at the operational level was accompanied by an increase in total recall, i.e., from $\bar{X} = 6.80$ to $\bar{X} = 8.00$. Once performance on one task was at the operational level, however, no appreciable increases were observed in total recall until four tasks were at the operational level, i.e., one task, $\bar{X} = 8.00$; two tasks, $\bar{X} = 8.29$; three tasks, $\bar{X} = 8.33$; and four tasks, $\bar{X} = 10.15$. Progress from four to five tasks at the operational level was accompanied by a further increase in total recall, i.e., from $\bar{X} = 10.15$ to $\bar{X} = 12.33$.

With respect to the learning disabled children, inspection of the means graphed in Figure 10 indicates that progress from zero tasks to one task at the operational level was accompanied by an increase in total recall, i.e., from $\bar{X} = 5.33$ to $\bar{X} = 6.91$. Progress from one to two tasks at the operational level was also accompanied by an increase in total recall, i.e., from $\bar{X} = 6.91$

to $\bar{X} = 8.36$. Once two tasks were at the operational level, no further increases in total recall were observed until four tasks were at the operational level, i.e., two tasks, $\bar{X} = 8.36$; three tasks, $\bar{X} = 8.30$; and four tasks, $\bar{X} = 9.45$. Progress from four tasks to five tasks at the operational level was not accompanied by an appreciable increase in recall, i.e., from $\bar{X} = 9.45$ to $\bar{X} = 9.75$. It should be noted, however, that only four learning disabled children were in the group demonstrating operational performance on five tasks.

When the data were organized in the manner presented in Table 19, the appropriate statistical procedure for looking at the relationships between the dependent variables, i.e., age, IQ and total recall, and the number of tasks upon which operational performance was demonstrated appeared to be a multivariate analysis. The decision to compare the recall ability of achieving and learning disabled children on the basis of the number of classification concepts which the children had mastered was based upon the information (and the insight!) gained from doing the research. A multivariate analysis had not been foreseen when the project was originally planned. It was felt that the results of such a rigorous analysis of the data in Table 19 would carry little weight in view of such factors as the small number of subjects in some cells relative to the number of dependant variables, the wide discrepancies between the numbers of subjects in the cells, etc. The experimenter was very curious, however, to know whether the results of a multivariate analysis would indicate any of the trends which

had been suggested to her by a descriptive analysis of the data. It was decided, therefore, to treat the data reported in Table 19 pertaining to the age, IQ and total recall of the subjects in the exploratory manner of a pilot study.

The age, IQ (PPVT) and total recall scores of achieving and learning disabled children who were operational on zero, one, two, three, four and five classification tasks were subjected to multivariate analysis (NYBMUL, 1969). The results will not be discussed in any detail, but it will be mentioned that the analysis indicated: (1) a significant main effect for diagnostic groups, $F\ (3,146) = 31.79$, $p<.0001$. Significant univariate F's were obtained under this main effect for IQ ($p<.0001$), and total recall ($p<.0001$), but not for age; (2) a significant main effect for number of tasks, $F\ (15,403.44) = 14.07$, $p<.0001$. Significant univariate F's were obtained under this main effect for age ($p<.0001$) and total recall ($p<.0001$), but not for IQ.

The multivariate procedure was used to compare the recall of the groups of children operational on different numbers of tasks with that of the remaining group. Results indicated: (1) recall of children operational on zero or one task was inferior ($p<.01$) to that of the remaining group; (2) recall of children operational on two or three tasks did not differ from that of the remaining group; and (3) recall of children operational on four tasks was superior ($p<.01$) to that of the rest of the children.

Analysis of the data presented in Table 19 and Figure 10 seems to indicate that, generally, achieving and learning disabled

children who had acquired the same number of classification concepts differed little with respect to total recall on the memory task. These groups of children, with the exception of those operational on zero to five tasks, did differ greatly with respect to age. Only between the groups of achieving and learning disabled children who were operational on four tasks did a major difference appear to exist for verbal IQ (PPVT).

The recall performance of the groups of achieving and learning disabled children operational on zero, one, two, three, four and five tasks suggests that superior recall appears to be associated with the degree of generalization of classification concepts which occurs when four and five of the tasks have been mastered. This phenomenon seems to be particularly evident in the achievers and is evident to a lesser degree in the learning disabled children.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

The present study was designed to seek answers to specific questions regarding: (1) the development of Piagetian classification concepts; (2) memory ability as indicated by performance on a levels of processing task; (3) the relationship between the level of development of the classification concepts and performance on the memory task by groups of achieving and learning disabled children. Twenty achieving and 20 learning disabled children were identified at each of four age levels, i.e., six to seven, eight to nine, 10 to 11, and 12 to 13 years. A total of 160 children participated in the investigation. A test battery consisting of five Piagetian classification tasks and a levels of processing memory task was administered individually to each child. In addition, the children were interviewed to obtain information regarding the use of mnemonic strategies for the recall of words processed on the memory task. The conclusions drawn from the results of the analysis of the data presented in the preceding chapter will be discussed for each question.

Questions Related to the Development of the Piagetian Classification Concepts

QUESTION 1: Is there a significant relationship between the age level of achieving children and stage of development on each of the five Piagetian tasks?

Achieving children demonstrated behavior characteristic of

the different stages of development described by Inhelder and Piaget (1964) for the five classification tasks. Significant relationships ($p<.05$) between age level and stage of development were observed for each task. Progress in the development of several of the classification concepts was observed when the performance of children at each of the three older age levels was compared with that of children at the immediately preceding age level. Eight to nine year olds demonstrated a higher level of development on the Additive Composition of Classes, Null Class and Duality Principle tasks than six to seven year olds. The performance of 10 to 11 year olds was superior to that of eight to nine year olds on the All and Some Conditions of Class Inclusion, Singular Class and the Duality Principle tasks, and the performance of 12 to 13 year olds was superior to that of 10 to 11 year olds on the Duality Principle task.

All possible pairs of the four different age levels were compared for performance differences with respect to each classification task. Whenever differences were significant ($p<.05$), the performance of older children was superior. These findings are in agreement with the suggestions of Inhelder and Piaget, that the stage of development of classification concepts in children is related to their chronological ages.

QUESTION 2: Is there a significant relationship between the age level of learning disabled children and stage of development on each of the five Piagetian tasks?

Learning disabled children demonstrated behavior

characteristic of the stages of development described by Inhelder and Piaget for each of the classification tasks. Significant relationships ($p<.05$) were found between several age levels of the children and the stage of concept development for each classification task. The performance of six to seven year olds did not differ significantly from that of eight to nine year olds with respect to any of the classification tasks. Not until children were 10 to 11 years of age was performance on all of the tasks significantly superior to that of the youngest children. The performance of 10 to 11 year olds was superior to that of eight to nine year olds only on the Null Class task. Not until children were 12 to 13 years of age was performance on the Additive Composition of Classes, Singular Class and Duality Principle tasks superior to that of the eight to nine year olds. The performance of 12 to 13 year olds was superior to that of 10 to 11 year olds on the Additive Composition of Classes and the Singular Class tasks.

Progress in the development of the classification concepts was not as marked in the learning disabled children as it had been in the achievers when the performance of children at immedidately adjacent age levels was compared. The slow development of classification concepts in these learning disabled children is in agreement with similar findings reported by Kirkbride (1977) and Klees and Lebrun (1972) and will be discussed in more detail shortly.

QUESTION 3: Is there a significant relationship between diagnostic group and stage of development on each of the five Piagetian tasks

with respect to achieving and learning disabled children at the same age level?

At each of the four age levels, achieving and learning disabled children differed significantly ($p<.05$) with respect to the level of development of some of the classification concepts. At the youngest age level the performance of achievers was superior to that of learning disabled children on the Singular Class and Null Class tasks. At both the eight to nine and 10 to 11 year age levels, the performance of achievers was superior to that of learning disabled children on the Additive Composition of Classes, Singular Class, Null Class and Duality Principle tasks. Achievers at the 12 to 13 year age level demonstrated performance on the Singular Class and Duality Principle tasks which was superior to that of learning disabled children at the same age level. At no age level did achieving and learning disabled children differ significantly with respect to performance on the All and Some Conditions of Class Inclusion task.

On the basis of the above results, it is suggested that learning disabled children demonstrated poorly developed classification concepts when their performance on Piagetian classification tasks is compared to that of achieving children at the same age level. This observation supports suggestions by Kirkbride (1977) and Klees and Lebrun (1972) that the classification skills of learning disabled children, as indicated by performance on Piagetian classification tasks, are inferior to those of achieving children at the same age level.

QUESTION 4: Is there evidence to support a concept of a developmental lag with respect to the age level at which learning disabled children acquire the five Piagetian classification concepts compared with achieving children?

In cases where achievers and learning disabled children at the same age level differed significantly ($p<.05$) with respect to the acquisition of classification concepts, the performance of the learning disabled children was compared with that of achievers at the next youngest age level. Comparison of the performance of the appropriate groups of children indicated: (1) learning disabled children at both the eight to nine and 10 to 11 year age levels were approximately two years behind achieving children at the same age level with respect to the development of the concepts of the Additive Composition of Classes, the Singular Class, the Null Class and the Duality Principle; and (2) learning disabled children at the 12 to 13 year age level were approximately four years behind achieving children at the same age level with respect to the development of the concepts of the Singular Class and the Duality Principle.

The concrete operational period of intellectual growth in the normal child extends roughly between seven and 11 years of age. The child initiates some aspects of formal operational thought at approximately 12 years of age (Ginsburg and Opper, 1969). According to the age norms proposed by Inhelder and Piaget (1964), concrete operational performance on the five classification tasks employed in the present investigation would be expected from

children at the 10 to 11 and the 12 to 13 year age levels. Indications of formal operational performance on the Null Class and Duality Principle would be expected from children at the 12 to 13 year age level.

The percentages of achieving and learning disabled children at the 10 to 11 year age level demonstrating operational performance on the classification tasks were as follows: Additive Composition of Classes, achievers, 95 percent and learning disabled, 50 percent; All and Some Conditions of Class Inclusion, achievers, 90 percent and learning disabled, 70 percent; Singular Class, achievers, 90 percent and learning disabled, 15 percent; Null Class, achievers, 100 percent (concrete operational, 15 percent; formal operational, 85 percent) and learning disabled, 80 percent (concrete operational, 45 percent; formal operational, 35 percent); Duality Principle, achievers, 75 percent (concrete operational, 60 percent; formal operational, 15 percent) and learning disabled, 15 percent (concrete operational 15 percent; formal operational, 0 percent).

The percentages of achieving and learning disabled children at the 12 to 13 year age level demonstrating operational level performance on the classification tasks were as follows: Additive Composition of Classes, achievers, 100 percent and learning disabled, 90 percent; All and Some Conditions of Class Inclusion, achievers, 100 percent and learning disabled, 80 percent; Singular Class, achievers, 100 percent and learning disabled, 50 percent, Null Class, achievers, 100 percent (concrete operational, 20 percent; formal operational, 80 percent) and learning disabled,

80 percent (concrete operational, 30 percent; formal operational, 50 percent); and Duality Principle, achievers, 100 percent (concrete operational, 30 percent; formal operational, 70 percent) and learning disabled, 30 percent (concrete operational, 25 percent; formal operational, 5 percent).

At both the 10 to 11 and 12 to 13 year age levels, achieving children are superior to learning disabled children with respect to the attainment of an operational level of performance on the Piagetian tasks. When performance is compared to the age norms proposed by Inhelder and Piaget (1964) for the development of classification concepts, the achieving children generally meet the criteria, the learning disabled children do not.

The classification concepts of learning disabled children appear to develop more slowly than those of achieving children. Two findings arising from the results of the present investigation which seem to support the concept of a developmental lag with respect to the age level at which learning disabled children acquire classification concepts are: (1) learning disabled children lag two to four years behind their achieving chronological age peers with respect to the acquisition of several classification concepts; and (2) learning disabled children do not meet the age criteria proposed by Inhelder and Piaget with respect to the development of the operational structure of classification. Factors which may partially explain the problems experienced by the learning disabled children with respect to the classification tasks will now be discussed.

Inhelder and Piaget (1964) stress that the actions performed by the child upon objects in his environment are the crucial factors which determine the development of classification. These authors suggest, however, that maturation, perception and language are factors which may be "necessary but not sufficient" for the completion of the operational structure of classification. Learning disabled children are frequently characterized in the literature as demonstrating maturational lags and perceptual and verbal deficits. The complex nature of these problems and the considerable impact they may have on the learning processes of children have been discussed and recognized elsewhere in this thesis.

The learning disabled children involved in the present investigation all had reading disabilities. The population appeared to be somewhat heterogeneous, however, with respect to perceptual and linguistic factors which might be contributing to their reading problems. For example, WISC-R scores available for learning disabled children in the three older age groups indicated that in 24 cases, the performance score was superior to the verbal score by 10 or more points; in four cases the verbal score was superior to the performance score by 10 or more points; and in 26 cases there was not a 10 point discrepancy between the verbal and performance scores.

School records and the children's teachers, especially the teachers of the two younger age groups, indicated that problems with auditory and visual recognition, discrimination and integration of sounds and symbols, difficulties with visual-motor

integration, and disturbances of spatial orientation were thought to be contributing to the reading problems that some of the learning disabled children were experiencing. Inhelder and Piaget (1964) suggest that at the very early stages of classification, children perceive similarities and differences among the objects to be classified. The writer suggests that perceptual difficulties experienced by some learning disabled children participating in this study may have inhibited their ability to focus upon the critical aspects of classification tasks. The ability of these children to perceive similarities and differences may have been impaired and consequently their progress with respect to the development of classification delayed.

A very close association between the development of classification and the development of language has been postulated by Inhelder and Piaget (1964). Data from the present study suggests that verbal deficits may have been major contributors to the problems that the learning disabled children experienced with the classification tasks. Twenty-four of the 60 learning disabled children in the three older age groups had WISC-R performance scores that were higher than their verbal scores by 10 or more points. This finding could be interpreted as indirect evidence of verbal deficits in these children (Rabinovitch, 1959, 1968; Vellutino, 1977).

The verbal IQ scores from school records for the three oldest groups of achieving and learning disabled children could not be compared statistically, since the scores of the former were derived

from group tests of intelligence and those of the latter were derived from individual tests of intelligence. Inspection of the mean verbal IQ scores for these groups indicated, however, that although all of the means were within the normal range, the verbal IQ's of the groups of achievers were higher than those of learning disabled children at the same age level.

The average verbal IQ of achievers ($\bar{X}$=110.1), as indicated by performance on the Peabody Picture Vocabulary Test (PPVT), was superior ($p<.001$) to that of learning disabled children ($\bar{X}$=102.9). The PPVT estimates verbal IQ by measuring receptive vocabulary. The mean PPVT scores obtained by the groups of achieving and learning disabled children at four different age levels were all within the normal range. Significant differences ($p<.05$) were observed, however, between the mean PPVT scores of achievers and learning disabled children at both the 10 to 11 and 12 to 13 year age levels. The mean scores of the achievers were superior in both cases.

Consideration of the verbal IQ scores obtained for the achieving and learning disabled children, from both school records and the PPVT, would seem to indicate that the language abilities of the learning disabled children are inferior to those of the achieving children. This finding is in agreement with Hallahan and Kauffman (1976), and would lend some support to the Vellutino (1977) that many children with reading problems have verbal deficits.

Language is particularly important when dealing with multiplicative and complex classifications such as those involved in the Singular Class and Duality Principle tasks (Inhelder and Piaget,

1964). Poor performance of the learning disabled children on these tasks may be due in part to their language deficits. Direct actions upon the concrete objects, i.e., squares and circles, presented to the child in the Singular Class task help to facilitate classification. Language skills, however, may assist the child in shifting from one classification criterion, i.e., shape, size, and color, to another. Only 15 learning disabled children compared with 52 achievers reached the concrete operational stage of the Singular Class task.

To reach the concrete operational stage of the Duality Principle task, children must deal with a complex animal classification. Inhelder and Piaget (1964) suggest that children cannot simply rely upon experience drawn from their own actions to say that ducks are birds and that birds are animals. In this situation children must rely heavily on "pure linguistic concepts and (they) may need to structure and develop these in the course of the actual experiment" (pp. 110-111). At the formal operational stage of the Duality Principle task, children must deal with the abstract classes not-ducks, not-birds, and not-animals and the complex relationship, animals > birds → not-birds > not-animals. Without well developed language skills, children probably cannot do this. Eight learning disabled children compared with 21 achievers were at the concrete operational stage of the Duality Principle, while only one learning disabled child compared with 17 achievers reached the formal operational stage of the task.

In summary, at all age levels the performance of learning disabled children was inferior to that of their achieving peers on two or more classification tasks. In addition, learning disabled children lagged two to four years behind their achieving peers with respect to their acquisition of several of the classification concepts. Poor classification skills appeared to be a general characteristic of the learning disabled children. Although the population of learning disabled children appeared to be heterogeneous with respect to perceptual and verbal deficits thought to be contributing to their academic problems, it is suggested that the population was quite homogeneous with respect to deficient classification abilities. The writer suggests that classification appears to be a broad based reasoning ability which may be vulnerable to different types of dysfunction, i.e., disturbances of perception and/or language.

QUESTION 5: Is there any evidence which indicates a priority of acquisition of the five Piagetian classification concepts by achieving and learning disabled children?

Examination of the Piagetian task data indicated that neither acheiving nor learning disabled children demonstrated an operational level of performance on a particular classification task or combination of tasks prior to others. It is suggested by the investigator that the numbers of children who are operational on the various tasks might serve as a very general index of the order of difficulty of the classification concepts. From this viewpoint, the order of task difficulty (from least difficult to most

difficult) for the achievers was: (1) Null Class; (2) All and Some Conditions of Class Inclusion; (3) Additive Composition of Classes; (4) Singular Class; and (5) Duality Principle. With the exception that the positions of the Null Class and All and Some Conditions of Class Inclusion tasks were reversed, the order of task difficulty for the learning disabled children was the same as for the achievers.

The order of task difficulty suggested here (with the exception of the Null Class which will be discussed separately) was not unexpected and is similar to the sequence of classification concept development proposed by Inhelder and Piaget (1964) and Kofsky (1966, see Figure 1, page 33 of this thesis). The concepts of Additive Composition of Classes and All and Some Conditions of Class Inclusion tended to be mastered prior to the concepts of the Singular Class and the Duality Principle.

To solve the various problems presented by the Additive Composition and All and Some tasks, the child must deal with the inclusion relations of a class hierarchy consisting of one supra-ordinate class and two subclasses, i.e., for Additive Composition, the supra-ordinate class of wooden beads and the subclasses of red and white beads; and for All and Some, a supra-ordinate class of square objects with subclasses of red and blue squares, and also a supra-ordinate class of blue objects with subclasses of blue squares and blue circles. The classifications involved in the Singular Class and the Duality Principle are more complex. The Singular Class requires the child to classify the same objects on

the basis of three different criteria, i.e., shape, size and color, and to recognize the special case of the complementary class that contains one object. The Duality Principle requires the child at the concrete operational stage to deal with the inclusion relations of a class hierarchy consisting of the supra-ordinate class of animals and three subclasses of farm animals, birds and ducks. The child at the formal operational stage of the Duality Principle task must deal with the symmetrical relationships between classes and their complements, i.e., animals > birds $\rightarrow$ not-birds > not-animals.

With three exceptions, children involved in the present investigation did not demonstrate operational level performance on the Singular Class task until they were operational on two of the following tasks, Additive Composition of Classes, All and Some Conditions of Class Inclusion and Null Class. It appears that some basic notions of the criteria of classes are necessary before the child can cope with the concept of the Singular Class. The importance of language with respect to mastering the Singular Class has been discussed in the preceding section.

No child involved in the present investigation demonstrated concrete operational performance on the Duality Principle task until at least three of the other classification concepts had been mastered. At the four tasks operational level, 10 children were concrete operational on the Duality Principle, and no child had reached the formal operational stage of this task. At the five tasks operational level, 19 more children were at the concrete operational stage, and 18 children were at the the formal

operational stage of the Duality Principle task. These results would seem to indicate that a degree of generalization of classification concepts, i.e., some basic understanding of class inclusion relations, is essential before children are capable of dealing with complex hierarchical classifications such as those involved in the Duality Principle. The child's need for well developed language skills to assist with the solution of the problems presented at the concrete operational stage and especially at the formal operational stage of the Duality Principle has already been discussed.

Of the 18 children, who reached the formal operational stage of the the Duality Principle task, 14 were achievers at the 12 to 13 year age level and had been at school for seven years. The writer is inclined to attribute the success of these children to their extensive experience with classifying objects and events and to the verbal facility related to such classification activities that the children developed during the seven school years.

The writer agrees with Lavatelli (1977) who suggests that the "not-class" is a concept which teachers frequently do not consciously discuss with children when teaching activities designed to develop classification abilities. Often teachers concentrate on having children assemble classes of similar objects and ignore the complementary class. For example, given an assortment of miniature trucks, airplanes and cars, the child is often asked to make separate classes of trucks, airplanes and cars, but is not asked to make up the class of trucks and the complementary class, not-trucks. The problems that the children involved in the present

investigation experienced with the classes of not-birds, not-animals, etc. at the formal operational stage of the Duality Principle task were discussed by the experimenter and the children's teachers. Many of the teachers indicated that they did not teach the concept of the complementary not-class when dealing with specified classes. The teachers were not surprised that the children could not deal with the concept.

Inhelder and Piaget (1964) have placed the concept of the Null Class, the complementary class which contains no objects, at the borderline of concrete and formal operational thought. The results of the present investigation do not support Inhelder's and Piaget's suggestion that the Null Class is a fairly advanced classification concept, since it was the easiest task for the achievers and the second easiest task for the learning disabled children to deal with. Donaldson (1960) has suggested that the Null Class is a rather sophisticated concept, and that the task proposed by Inhelder and Piaget (1964) to test for it is inadequate. The results of the present study would seem to support Donaldson (1960).

According to Inhelder and Piaget (1964) when children between the ages of five and 12 years are presented with a collection of blank cards (representing the Null Class) and cards with pictures on them, children younger than 10 to 11 years of age tend to avoid making a dichotomy of blank and picture cards. With respect to the present investigation, 37.5 percent of the achieving children below the age of 10 years spontaneously produced a dichotomy of the cards (stage 4a, formal operations), and another 32.5 percent could be

led to produce a dichotomy by the experimenter (stage 3, concrete operations). On the other hand, only five percent of the learning disabled children below the age of 10 years spontaneously produced a dichotomy of the cards, and only another 15 percent of these children could be led to produce the dichotomy by the experimenter. Despite the rather unexpected position of the Null Class in the order of task difficulty for achieving and learning disabled children, and the dubious nature of the task used to test for it, the Null Class appears to be a difficult concept for the young disabled children. The difficulties experienced by these young children in dealing with the Null Class may be due to the perceptual and linguistic problems which they seemed to experience.

In summary, the order of classification task difficulty was very similar for the groups of achieving and learning disabled children. Overall, the order of task difficulty was similar to the order of acquisition of classification concepts proposed by Inhelder and Piaget (1964) and Kofsky (1966).

<u>Questions Related to Performance on the Levels of Processing Task</u>

QUESTION 1: Is memory developmental within the population of achieving children; do older children recall more words than younger children?

Some age related trends were observed with respect to the development of memory ability within the population of achieving children. Comparison of the mean total recall scores obtained on the levels of processing task by achievers at immediately adjacent age levels indicated: (1) no significant differences in recall

between the six to seven and eight to nine year olds; (2) the recall of the 10 to 11 year olds was superior ($p<.01$) to that of the eight to nine year olds; and (3) no significant differences in recall between the 10 to 11 and 12 to 13 year olds. In addition, the mean total recall performance of achievers at both the 10 to 11 and 12 to 13 year old age levels was superior ($p<.01$) to that of achievers at both the six to seven and eight to nine year old age levels.

The general conclusion drawn from these results was, that within this population of achieving children, the total recall performance on the levels of processing task by children older than 10 years of age was superior to that of achievers younger than 10 years of age. Similar results have been reported for the performance of normal children on a levels of processing memory task by Kirkbride (1978a) and Snart (1979).

The better memory ability of the children older than 10 years of age may be related to a general shift from pre-operational to concrete operational thinking, as indicated by their performance on the Piagetian classification tasks. The percentages of achieving children operational at the younger (<10 years) and older (>10 years) age levels with respect to the various classification tasks were as follows: Additive Composition of Classes, 45 and 97.5 percent; All and Some Conditions of Class Inclusion, 57.5 and 95 percent; Singular Class, 35 and 95 percent; Null Class, 70 and 100 percent; and Duality Principle, 7.5 and 87.5 percent.

According to Inhelder and Piaget (1964), the development of

the operational structure of classification contributes to the growth of logical thinking processes in children. The marked progress in logical thinking processes in the older group of achieving children, as indicated by their performance on the classification tasks, may be reflected in their superior performance on the memory task compared with that of the younger group of children who did not exhibit the same degree of operational performance on the classification tasks. These results tend to support suggestions by Brown (1975, 1979) and Chi (1976, 1977) that the child's memory ability is related to his current knowledge base.

The mean total recall scores of achievers at the 10 to 11 and 12 to 13 year age levels were 12.05 and 12.30, respectively. These two groups of children did not differ in recall performance despite the observation that only 15 percent of the 10 to 11 year olds, compared to 70 percent of the 12 to 13 year olds, demonstrated formal operational thinking on the Duality Principle task. The Duality Principle was the only classification task on which the performance of these two groups of achieving children had differed significantly ($p<.001$). The formal operations described by Inhelder and Piaget (1964) with respect to the Duality Principle have been discussed previously and involved the duality between the ordering of classes and the ordering of their complements and is expressed $(A) < (B) \rightarrow (\text{not-}A) > (\text{not-}B)$. It is suggested that the acquisition of these particular formal operations does not enhance the recall performance of children on the memory task employed in this investigation.

QUESTION 2: Is memory developmental within the populations of learning disabled children, do older children recall more words than younger children?

The mean total recall scores obtained by learning disabled children at four different age levels on the levels of processing task indicated several age related trends with respect to the development of memory ability within this population of children. Comparisons of the mean total recall scores of learning disabled children at immediately adjacent age levels indicated: (1) the recall of eight to nine year olds was superior ($p<.01$) to that of the six to seven year olds; (2) no significant differences in recall between the eight to nine and 10 to 11 year olds; and (3) no significant differences in recall between the 10 to 11 and 12 to 13 year olds. In addition, the recall of the 10 to 11 year olds was superior ($p<.01$) to that of the six to seven year olds, and the recall of the 12 to 13 year olds was superior ($p<.01$) to that of both the six to seven and eight to nine year olds. These results are in agreement with similar findings reported by Kirkbride (1978a) with respect to the performance on a levels of processing task by learning disabled children at different age levels.

The total recall results of achieving children which were discussed previously indicated that the recall of achievers older than 10 years of age was superior to that of achievers younger than 10 years of age. A similar situation did not appear to exist for the learning disabled children. Not until learning disabled children were 12 to 13 years of age was their recall superior ($p<.01$)

to that of learning disabled children at both the six to seven and eight to nine year age levels.

A major shift from pre-operational to operational thinking, as indicated by performance on the classification tasks, appeared to occur in the achieving children around the age of 10 years. The percentages of learning disabled children operational at the younger (<10 years) and older (>10 years) age levels with respect to the various classification tasks were as follows: Additive Composition of Classes, 20 and 70 percent; All and Some Conditions of Class Inclusion, 37.5 and 75 percent; Singular Class, 5 and 32.5 percent; Null Class, 20 and 80 percent; and Duality Principle, 0 and 22.5 percent. A shift from pre-operational to concrete operational thinking did occur in the learning disabled children. The percentages of older learning disabled children who were operational on the classification tasks (especially the Singular Class and Duality Principle) were much smaller, however, than the percentages of older achieving children who had attained an operational level of performance on the tasks. It is suggested that the slow transition from pre-operational to operational thinking, as indicated by the apparent slow development of classification concepts in the learning disabled children, is reflected in their performance on the levels of processing task.

QUESTION 3: Is the total recall of achieving children superior to that of learning disabled children at the same age level?

The total recall performance of achieving children on the levels of processing task was superior ($p<.01$) to that of learning

disabled children at the six to seven, 10 to 11, and 12 to 13 year age levels. No significant differences were observed between the mean total recall scores of achieving and learning disabled children at the eight to nine year age level.

Comparison of the recall performance of learning disabled children at both the 10 to 11 and 12 to 13 year age levels with that of achievers at the next youngest age level indicated: (1) the recall performance of learning disabled children at the 10 to 11 year age level lagged two years behind that of achievers at the same age level ($p<.01$); and (2) the recall performance of learning disabled children at the 12 to 13 year age level lagged four years behind that of achievers at the same age level($p<.01$). As discussed previously, when the performance of these same groups of learning disabled children was compared with that of achievers, lags of the same magnitude had occurred with respect to the acquisition of several of the classification concepts.

The greatest difference between the mean total recall scores of achieving and learning disabled children occurred at the 10 to 11 year age level (achievers $\bar{X}=12.05$; learning disabled, $\bar{X}=8.05$). A major shift from pre-operational to concrete operational thinking, as judged by performance on the classification tasks, occurred in the achievers at about 10 years of age. Learning disabled children also demonstrated a shift from pre-operational to operational thinking at about 10 years of age. The degree of shift, however, as discussed previously, was not as great in the learning disabled children as in the achieving children. It is suggested by the

present investigator that the slow acquisition by the learning disabled children of the logical thinking processes, i.e., the classification concepts, described by Inhelder and Piaget (1964) may contribute to the developmental lags which appear to exist when the memory performance of learning disabled children is compared with that of achievers at the same age level.

QUESTION 4: Will the recall scores obtained by achieving and learning disabled children at four different age levels support the Craik and Lockhart (1972) position, that on a test of recall for words processed at physical, phonemic, and semantic levels, the hierarchy of recall will be semantic > phonemic > physical?

The scores obtained by achieving and learning disabled children for three levels of processing were subjected to a three-way analysis of variance 2 (groups) x 4 (age levels) x 3 (levels of processing), the levels factor repeated within, to determine whether the results of the present investigation would provide support for the Craik and Lockhart (1972) suggestion that the hierarchy of recall for words processed at physical, phonemic, and semantic levels is semantic > phonemic > physical. The results of the analysis of variance which were relevant to this question indicated a significant main effect for levels of processing ($p<.01$) and a significant levels of processing x age levels interaction ($p<.05$). The levels of processing x diagnostic groups interaction and the levels of processing x age levels x diagnostic groups interaction were not significant at the .05 level.

Multiple comparisons of the mean involved in the levels of

processing x age levels interaction provided information regarding: (1) the recall of physical, phonemic and semantic level words by children at each individual age level; and (2) significant age trends with respect to the recall of words encoded at each of the different levels of processing.

Within each of the four different age levels (data collapsed over groups) the recall of semantic encodings was superior ($p<.05$) to the recall of both phonemic and physical encodings. The recall of physical and phonemic encodings did not differ significantly at any age level. These results provide only partial support for the suggestion by Craik and Lockhart (1972) that the hierarchy of recall for words processed at the physical, phonemic and semantic levels is semantic > phonemic > physical. Semantic encodings were best remembered by children at all four age levels. The recall of phonemic level words, however, was not superior to the recall of physical level words. These findings are in agreement with results reported by Kirkbride (1978a), Geis and Hall (1976) and Owings and Baumeister (1979).

Significant age trends observed with respect to the recall of physical, phonemic and semantic level words by children at the four different age levels (data collapsed over groups) were: (1) six to seven year olds recalled fewer physical level words than either the 10 to 11 ($p<.05$) or the 12 to 13 (p .01) year olds; (2) six to seven year olds recalled fewer semantic level words than children at each of the three older age levels ($p<.05$); and (3) eight to nine year olds recalled fewer semantic level words than 12 to 13 year olds ($p<.01$). There were no significant differences between

any of the age levels with respect to the recall of phonemic level words. Neither these results, nor the results pertaining to the recall of words encoded at different levels of processing by children within each individual age level, supports the suggestion that young children tend to recall the phonemic attributes of words, while children aged eight years and older tend to recall semantic attributes (Naron, 1978; Hasher and Clifton, 1974).

The levels of processing x diagnostic groups interaction was not significant at the .05 level. Comparison of several means involved in this interaction, however, indicated that as a group, achievers recalled more phonemic and semantic level words ($p<.01$) than learning disabled children. The inferior recall of phonemic level words by the learning disabled children might be considered a reflection of either deficits in auditory perception (Wepman, 1960, 1961) or disturbances in the phonological aspects of language (Blank, 1968; Vellutino, 1977; Shankweiler and Liberman, 1976). The inferior recall of semantic level words by the learning disabled children could be construed as evidence of dysfunction in semantic components of language (Vogel, 1975, cited in Cummins and Das, 1977; Vellutino, 1977; Denckla and Rudel, 1976).

As a group, the learning disabled children involved in the present study did appear to have more language problems than the achieving children. The writer proposes, however, that the poor recall of both phonemic and semantic level words by the learning disabled children is primarily due to their inefficient use of category organization as a mnemonic strategy. In addition, it is

suggested here that the failure of the learning disabled children to efficiently use category organization as a means for recalling information is related to the poor development of classification skills in these children. These suggestions are discussed in the following sections.

QUESTION 5: Will the interview information provide any indications as to how both the achieving and learning disabled children retrieve from memory the stimulus words involved in the levels of processing task?

The only mathematical analysis to which the interview data was subjected was the calculation of the mean number of categories mentioned by the achieving and learning disabled children during their descriptions of their information retrieval processes. The explanations and conclusions which are presented here are based upon: (1) a consideration of the category means; and (2) an attempt to merge the writer's general overview of the interview data with her interpretation of statistical results obtained from the analysis of the classification and memory task data.

When initially questioned about the means they had used to remember the words reported on the levels of processing recall test, it was not unusual for achieving and learning disabled children to respond that they did not know how they had remembered the words. When coaxed to give further consideration to the matter of information retrieval, the children often replied that they had remembered the words by thinking about the questions the experimenter had asked about the words. For example, "Is this word a

type of something, like fruit, or clothes?" or "Does this word rhyme with something, like 'shed' or 'bed?'"

Asked why specific semantic level words like "bomb" or "peach" had been recalled, children frequently replied that the words had belonged to a particular category of item ... "it's a weapon" ... or ... "it's a fruit." Sometimes the reason given by children for the recall of words, for which the orienting questions were intended to induce physical or phonemic processing, was that they also belonged to categories of items. For example, many children reported recalling the word "gun" because it is a weapon. The orienting question for which gun was the stimulus word was ... "Does this word start with a G?" The word "bus" was often recalled because it was a vehicle although the orienting question for bus had been ... "Does this word rhyme with fuss?"

Any categories mentioned by the children during their explanations of their retrieval of the stimulus words were recorded by the experimenter. The mean numbers of categories reported by achieving and learning disabled children at the four age levels were as follows: six to seven years, achievers 1.10, learning disabled 0.40; eight to nine years, achievers 2.80, learning disabled 1.20; 10 to 11 years, achievers 4.10, learning disabled, 2.00; and 12 to 13 years, achievers 4.00, learning disabled 2.45. Inspection of the means indicates that within the populations of both achieving and learning disabled children more categories were reported by children older than 10 years than by children younger than 10 years. Observation of the category means also indicates that

learning disabled children reported fewer categories than achieving children at the same age level. Similar findings that learning disabled children do not effectively use category organization for the recall of information have been reported by Bauer (1979), Torgesen (1977), Dellago and Moely (1979), and Parker, Freston and Drew (1975).

The writer suggests that there is a parallel between the number of category labels recalled by achieving and learning disabled children and: (1) the level of development of their classification concepts; and (2) their recall of words processed at the semantic level. The analysis of the classification task data indicated that the classification concepts of both achieving and learning disabled children older than 10 years of age were more highly developed than those of children younger than 10 years of age. The classification concepts of the achievers, as indicated by performance on the Piagetian tasks, were more advanced than those of learning disabled children at the same age level. The results of the analysis of the levels of processing data indicated that, although achieving and learning disabled children at all age levels best remembered words processed at the semantic level, older children tended to remember more semantic encodings than younger children. In addition, achievers recalled more semantic encodings than learning disabled children.

According to Craik and Lockhart (1972), semantic processing involves the assimilation of information to existing cognitive structures. The writer suggests that when presented with semantic

orienting questions which ask, for example, if a particular word such as "peach" or "shirt" is a type of "fruit", children assimilate the information to the cognitive structure of classification (Inhelder and Piaget, 1964) which they possess. To decide whether a peach or a shirt represents a type of fruit children utilize their current knowledge regarding: the intension, i.e., the set of properties common to members of a class and the set of differences which distinguish them from another class; the extension, i.e., the list of members belonging to a class; and the inclusion relations of the classes of "fruit" and "peach" or of "fruit" and "shirt."

A meaningful classification process involved at the time of encoding of semantic level words could contribute to the production of strong and durable memory traces for these words. At the time of recall, it appears that children involved in this investigation often remembered not only the semantic level word, but also what they did at the time of encoding. The children frequently indicated that they remembered the words by thinking about the questions. It is suggested here that recall of classification procedures, used at the time of semantic processing, prompted children to use category cues to search for words which had been processed at shallower physical and phonemic levels. It appears, for example, that children often remembered "gun" because it was a weapon not because it started with a "G." The word "bus" was often remembered because it was a vehicle not because it rhymed with "fuss."

Many children participating in the present study did seem to know something about how their memories worked, and seemed to

possess metamemorial skills described by Flavell (1977) and Kreutzer, Leonard and Flavell (1975). The facility with which the children used the mnemonic strategy of category organization for encoding and retrieving information appears to have been related to the level of development of their classification concepts. This suggestion would tend to support previous research (Lunzer, 1977; Trepanier, 1978; Piaget and Inhelder, 1973; Tomlinson-Keasey, Crawford and Eisert, 1979) and could partially explain differences in memory performance between younger and older children and between achieving and learning disabled children.

QUESTION 6: Following spontaneous recall, will achieving and learning disabled children effectively use cues, provided in the form of category labels to recall more words?

The experimenter suggested any categories not mentioned by the children during their descriptions of the means they had used to recall words on the levels of processing task. A cued recall score was thus obtained for each child. The mean cued recall scores for achieving and learning disabled children at the four age levels were as follows: six to seven years, achievers 4.40, learning disabled 5.45; eight to nine years, achievers 4.45, learning disabled 5.05; 10 to 11 years, achievers 2.15, learning disabled 4.50; and 12 to 13 years, achievers 2.15, learning disabled 3.90.

Inspection of the cued recall means indicates that when both achieving and learning disabled children were supplied with category labels as cues, they were able to use the cues to recall more information. The higher cued recall scores for younger

children compared to older children and for learning disabled children compared to achievers were expected since the free recall scores and category scores for the former compared to the latter groups had been lower.

As previously discussed, the learning disabled children involved in this investigation manifested more language problems than their achieving peers. Efficient use of category cues by the learning disabled children for recall of information, however, tends to support Torgesen (1980). According to Torgesen, if deficient language skills were solely responsible for differences in memory ability between children with and without reading disabilities, it would not be expected that supplying cues to assist in the recall of information, or minimal training in the use of mnemonic strategies (Torgesen, 1977), would have such a "powerful effect in reducing difference between groups" (Torgesen, 1980, p. 369).

The younger achieving children and many of the learning disabled children at all age levels may have experienced production deficiencies or production inefficiencies with respect to the use of the mnemonic strategy of category organization (Flavell, 1970; Moely, Olsen, Halwes and Flavell, 1969). Torgesen (1980) has postulated that the slow development of mnemonic strategies in learning disabled children may be related to the slow development of the basic skills required to execute the strategies. The failure of learning disabled children in the present investigation to spontaneously and/or efficiently use category cues for the recall of information appears to be related to the finding that

the classification concepts of these children were not well developed.

The ability of so many of the learning disabled children involved in the present investigation to use category labels, provided by the experimenter, for the efficient recall of information suggests that the memory problems of these children were perhaps more a matter of information retrieval than of initial encoding and storage of information. Since the children were able to recall more words when provided with appropriate category labels, it would appear that the children were able to attend to the original orienting tasks and to assimilate the information which was presented to them.

Questions Regarding the Relationship Between the Development of the Piagetian Classification Concepts and Recall on the Levels of Processing Task

Some possible links between the operative level of development of the classification concepts in achieving and learning disabled children and their performance on the levels of processing memory task were suggested and discussed in the preceding section which dealt with the conclusions arising from the results of the analysis of the memory task data. Among the original questions posed for investigation in the present study were two which required a direct comparison between the classification task and memory task results. The conclusions reached with respect to these two questions will now be discussed.

QUESTION 1: Will recall on the memory task by achieving and learning disabled children increase as the stage of development on the classification tasks increases?

Generally, as the stage of development on each of the five classification tasks increased, the mean total recall scores obtained by both achieving and learning disabled children on the levels of processing task also increased. Higher total recall scores were associated with higher stages of classification concept development. The memory ability of the children involved in the present investigation appears to have been related to the level of cognitive development in the children as indicated by their performance on the classification tasks. These results would tend to support Piaget and Inhelder (1973) who postulate that children's memory abilities are integrally linked to the operational schemata they possess, and that a direct relationship thus exists between memory ability and the stage of cognitive development.

QUESTION 2: Will the recall of achieving and learning disabled children who are at the same stage of development on the same classification task differ?

Inspection of the total recall means obtained by achieving and learning disabled children who were at the same stage of development on the same classification tasks indicated that the recall of the achievers was higher. Comparison of the means indicated that significant differences ($p<.05$) occurred between the total recall of achievers and learning disabled children at the stages of each of the five classification tasks at which the children demonstrated

either concrete or formal operational performance, i.e., stage 3 or 4. For example, the mean total recall scores of achievers and learning disabled children at stage 3 of the All and Some Conditions of Class Inclusion task were 10.70 and 8.20, respectively. The highest mean total recall scores were obtained by the groups of achievers and learning disabled children who were at the concrete operational stage of the Duality Principle task, i.e., achievers, 12.24 and learning disabled, 10.13.

Analysis of the classification task data indicated that the Duality Principle was the most difficult task for both achieving and learning disabled children to deal with. No child demonstrated concrete operational performance on the Duality Principle task until at least three of the other four classification tasks included in the test battery had been mastered. It is suggested that the higher recall scores, obtained by both achieving and learning disabled children at the concrete operational stage of the Duality Principle task, are a reflection of the level of cognitive development associated with the generalization of classification concepts (the basic understanding of class inclusion relations) and language development which seems to be essential for the mastery of this concept.

On the basis of the conclusions drawn regarding the possible association between the degree of generalization of classification concepts and recall ability in achieving and leraning disabled children, the data were considered in a manner which had not been foreseen when the research project was designed. It was decided that the relationship between the development of the classification

concepts and the recall ability of the children, might best be studied by relating recall to the degree of generalization of classification concepts in the children, i.e., to the number of concepts which they had mastered. With hindsight (gained from having carried out the project and analyzing the results) the achieving and learning disabled children were grouped separately according to whether they were operational on zero, one, two, three, four or five classification concepts.

The mean total recall scores of achieving children who were operational on zero, one, two, three, four and five classification tasks were 6.80, 8.00, 8.29, 8.33, 10.15, and 12.33, respectively. The mean total recall scores of learning disabled children who were operational on zero, one, two, three, four and five classification tasks were 5.33, 6.91, 8.36, 8.30, 9.45, and 9.75, respectively. With the exception of the groups of achieving and learning disabled who were operational on five tasks (four learning disabled and 33 achieving children were involved in this comparison), the recall of the groups of achieving and learning disabled children who were operational on the same number of classification tasks does not appear to differ greatly.

Although there was little difference between the mean total recall scores of the groups of achieving and learning disabled children who were operational on one, two, three and four classification concepts, the mean age differences between these same groups of children were 22, 30, 22 and 36 months, respectively. The learning disabled children were much older than the achievers. The lack

of differences between the mean ages of the groups of achieving and learning disabled children who were operational on zero and on five classification tasks, is due to the original selection criteria which assigned subjects to discrete age levels. No child included in the study was younger than six years or older than 13 years of age.

Inspection of the total recall means of the groups of achieving children who had mastered zero to five classification concepts suggests: (1) recall increases between zero and one task; (2) recall does not differ among the children operational on one, two and three tasks; (3) recall increases between three and four tasks; and (4) recall increases between four and five tasks. These results suggest that superior memory ability is associated with the degree of generalization of classification concepts which occurs when four and five of the tasks have been mastered.

With respect to the groups of learning disabled children who were operational on zero to five classification tasks, inspection of the total recall means indicates that recall increases as the number of classification concepts mastered increases (except in the case of two and three tasks where the means were 8.36 and 8.30, respectively). For achievers progress from four to five tasks operational is marked by an appreciable increase in total recall. This is not the case, however, for the learning disabled children.

When the achieving and learning disabled children were grouped according to the number of classification concepts they had mastered, the data pertaining to age, verbal IQ (as indicated by receptive

vocabulary scores on the PPVT) and total recall were subjected to a multivariate analysis. As discussed previously, because of the nature and the form of data, i.e., small numbers in the cells, wide discrepancies in cell sizes, etc., the analysis was done and treated in the exploratory manner of a pilot study to determine whether some implications relevant to further research might be indicated.

The results of the multivariate analysis indicated some support for the suggestions and conclusions proposed here on the basis of a descriptive analysis of the performance of achieving and learning disabled children who were operational on the same number of classification concepts. The multivariate analysis suggested: (1) a main effect for diagnostic groups ($p<.001$) and for the variables contributing to this main effect the univariate F's for IQ and total recall were significant ($p<.0001$), the univariate F for age was not significant; and (2) a main effect for number of operational tasks ($p<.0001$) and for the variables contributing to this main effect the univariate F's for age and total recall were significant ($p<.0001$), the univariate F for IQ was not significant.

The multivariate analysis also indicated support for the suggestion that superior memory ability is associated with the degree of generalization of classification concepts. Results indicated that: (1) the mean recall of children operational on zero or one classification task was inferior to that of the remaining children; (2) the mean recall of children operational on two or three classification tasks did not differ from that of the remaining children; and (3) the mean recall of children operational on four

classification tasks was superior to that of the remaining children.

In summary, an attempt was made in the present investigation to study the relationship between two cognitive processes in achieving and learning disabled children. The author tried to relate the level of development of the children's classification concepts, as indicated by their performance on Piagetian tasks, to their memory ability, as indicated by their performance on a levels of processing task. The author hypothesized that knowledge of the criteria of classes and class inclusion relations would be helpful to the children with respect to the encoding and retrieval of information on the memory task.

When the performance of achieving and learning disabled children at the same age level was compared, it was most often found that both the classification concepts and the memory ability of the achievers were superior. Developmental lags of two to four years, with respect to the acquisition of several classification concepts, were observed in the three oldest groups of learning disabled children when their performance was compared with that of achievers at the same age level. In addition, the memory ability of learning disabled children at the two oldest age levels lagged two years and four years, respectively, behind that of their achieving chronological age peers. It seemed obvious, that compared to achievers at the same age level, learning disabled children did poorly on all of the tests.

It was observed that as the degree of generalization of classification concepts increased in both achieving and learning disabled children their recall ability also seemed to increase. Consequently,

achieving and learning disabled children were grouped according to the number of classification concepts upon which they demonstrated operational performance. Comparison of the mean recall scores of the groups of achieving and learning disabled children who were operational on the same number of tasks indicated that, generally, there was little difference in recall between the groups (except for children operational on five tasks). The groups of learning disabled children who were operational on one, two, three and four tasks were much older than the corresponding groups of achievers. The groups of learning disabled children and achievers who were operational on zero and five tasks did not differ in age due to the original selection criteria of age levels.

It appeared that achieving and learning disabled children in whom the operational structure of classification was developed to the same degree, generally performed equally well on the memory task. This finding is in agreement with results reported by Trepanier (1978) for learning disabled children involved in a replication study of Piaget's memory research. The findings of the present investigation lend general support to Piaget and Inhelder's (1973) suggestion that intelligence and memory are inseparable and follow one another in stages that are related to the operative level of the child's intellectual development. The writer concludes that there is much merit in looking at the memory ability of both achieving and learning disabled children in terms of "applied cognition."

Summary of Conclusions

The major findings of this investigation were:

1. Within the populations of both achieving and learning disabled children, significant relationships were observed between age level and stage of development for each classification concept. Whenever differences occurred between the performance of children at different age levels, the performance of older children was always superior to that of younger children.
2. Comparison of the performance of achieving and learning disabled children at the same age level indicated significant relationships between diagnostic group and stage of development for two or more of the following classification concepts; Additive Composition of Classes, Singular Class, Null Class and Duality Principle. The concepts for which the differences occurred varied at the different age levels but the performance of achievers was always superior to that of learning disabled children.
3. The classification concepts of the learning disabled children appeared to develop in the same way as those of achievers, but at a slower rate. There was some evidence to support a theory of developmental lag (in the order of two to four years) with respect to the age at which some of the learning disabled children acquired the concepts of Additive Composition of Classes, Singular Class, Null Class and Duality Principle compared to the age at which

achievers acquired the same concepts.

4. The learning disabled children participating in this investigation all possessed at least average intellectual potential and demonstrated marked academic underachievement, especially in reading. The population of children was heterogeneous in that both perceptual and verbal deficits were thought to be contributing to their learning disabilities. The population appeared to be homogeneous, however, in that poor classification skills seemed to be a general characteristic of the learning disabled children. It was suggested that classification may be a broad based mental activity which may be vulnerable to different types of dysfunction, i.e., disturbances of perception and/or language.
5. Children did not become operational on the same classification task or combination of classification tasks at the same time. The order of task difficulty (from least difficult to most difficult) for achievers appeared to be: (1) Null Class; (2) All and Some Conditions of Class Inclusion; (3) Additive Composition of Classes; (4) Singular Class; and (5) Duality Principle. With the exception that the positions of the Null Class and All and Some Conditions of Class Inclusion were reversed, the order of task difficulty was the same for learning disabled children.
6. No child demonstrated concrete operational performance on the Duality Principle task until at least three of the

other classification concepts had been mastered. It was suggested that some degree of generalization of classification concepts (some basic understanding of class inclusion relations) and well developed language skills were essential before the children could deal with the complex classifications involved in the Duality Principle task.

7. Within the populations of both achieving and learning disabled children, age related trends were observed with respect to the development of memory ability. The recall of achievers older than 10 years of age was superior to that of achievers younger than 10 years of age. Not until learning disabled were 12 to 13 years of age was their recall superior to that of children at both the six to seven and eight to nine year age levels. It was suggested that the major shift from pre-operational to concrete operational thinking which occurred in the achieving children around the age of 10 years, as indicated by their performance on the classification tasks, was reflected in the superior memory ability of the older children. A shift from pre-operational to concrete operational thinking occurred in the learning disabled children around the age of 10 years. The magnitude of the shift, however, was much less in the learning disabled children.

8. The total recall of achieving children was superior to that of learning disabled children at the same age level except in the case of the eight to nine year olds. The

recall ability of learning disabled children at the 10 to 11 year age level lagged two years behind that of achievers at the same age level, while the recall ability of learning disabled children at the 12 to 13 year age level lagged four years behind that of achievers of the same age level. It was suggested by the investigator that the slow acquisition by the learning disabled children of logical thinking processes, i.e., classification concepts, described by Inhelder and Piaget (1964), contributed to the developmental lags which appeared to exist when the memory performance of the learning disabled children was compared with that of achievers.

9. Partial support was obtained for the Craik and Lockhart (1972) suggestion that the hierarchy of recall for words processed at physical, phonemic and semantic levels is semantic > phonemic > physical. The recall of semantic encodings by children involved in the present investigation was superior to the recall of both phonemic and physical encodings. The recall of phonemic and physical encodings, however, did not differ.

10. As a group, achievers recalled more semantic and phonemic encodings than learning disabled children. The groups did not differ with respect to the recall of physical encodings.

11. During interviews, many children indicated they had used category labels as a mnemonic strategy for the recall of

information. The use of category labels was reported more frequently by older children than by younger children and more frequently by achieving than by learning disabled children. It was suggested that the facility with which the achieving and learning disabled children used category organization as a strategy to recall information was related to the operative level of their classification concepts.

12. Both achieving and learning disabled children were able to efficiently use cues, provided by the experimenter in the form of category labels, to recall further information following the spontaneous recall test.
13. Generally, as the stage of development on each of the five classification tasks increased, the mean total recall scores obtained by both achieving and learning disabled children who were at the stage also increased. The highest recall scores were obtained by children at the concrete operational stage of the Duality Principle task. These scores were suggested to be a reflection of the level of cognitive development associated with the generalization of classification concepts which seem to be essential for master of the Duality Principle. It was decided, therefore, that the best way to study the relationship between the level of development of classification concepts and the recall ability of the children would be to relate recall to the degree of generalization of classification concepts in the children, i.e., to the number of concepts they had

mastered.

14. With the exception of the groups of achieving and learning disabled children who were operational on five tasks, the recall of the groups of achieving and learning disabled children who were operational on the same number of classification tasks did not appear to differ greatly. The groups of achieving and learning disabled children who were operational on one, two, three and four tasks did differ greatly, however, in age, i.e., 22 to 36 months. The learning disabled children were much older than the achievers. The overall conclusion drawn from these findings was that achieving and learning disabled children in whom the operational structure of classification was developed to the same degree tended to perform equally well on the memory task.

15. The experimenter was able to test only very modest numbers of children. Caution must be exercized in generalizing from the results of investigations involving small samples. The results of this study may provide helpful insight as to the problems experienced by learning disabled children and indicate possible avenues of further research.

RECOMMENDATIONS

1. In view of the developmental lags suggested in this thesis with respect to the acquisition of classification and memory abilities by learning disabled children, the writer urges and strongly recommends the early identification of

these children. Often learning disabled children are not identified until they have been at school for several years. The academic progress of young learning disabled children appears to be slower than that of their achieving peers, and tolerant educators should recognize and accept this fact as early as possible. Gearing initial curricula to the special needs of learning disabled children, and regulating the demands of the curricula to the children's progress, is preferable to attempting to "patch up" or "fix" numerous academic problems and deficits which have accumulated over a period of years. In addition, early identification affords school personnel the opportunity to foster self-esteem in the learning disabled child from the beginning of his scholastic career. It is much more difficult to bolster the self-esteem of a child with a long history of scholastic failure.

2. The writer recommends that direct intervention by educators with respect to the learning processes of learning disabled children may be essential. Although intellectual development may well, as Piaget suggests, have its origin in the interactions which occur between children and the environment, the influence of a favourable educational environment cannot be ignored. The presence of a perceptive teacher who can act as a mediator (Feuerstein, 1979) and intervene between the environment and learning disabled children in order to assist them in focusing on key aspects of the

tasks which confront them seems, to the writer, to be absolutely essential. Many learning disabled children involved in the present study did not spontaneously and/or efficiently use category labels for the recall of information. When the experimenter supplied category labels to these children, however, many of them were able to use the cues efficiently for the recall of information. These results suggest that there may be benefits in instructing learning disabled children in the use of cognitive strategies which they do not spontaneously and/or efficiently employ.

3. It is recommended that the education of adolescent learning disabled children should be carefully monitored. Many of the oldest learning disabled children involved in this investigation had not acquired basic intellectual skills, i.e., classification concepts, which have been suggested to be necessary for logical thinking and academic achievement. There is a tendency in some educational systems to place adolescent learning disabled children in pre-vocational classes in order to prepare them for entry to a vocational or trade school. It is possible, that once the educational system has committed the learning disabled child to vocational training, much of the intellectual potential the child possesses may not develop. Unfortunately, the maintenance of learning disabled children in the regular school system is often not a matter of the right education for the

child, but rather a political matter of how much money is available. It is recommended here that authorities responsible for the education of adolescent learning disabled children should consider programs such as those developed by Feuerstein (1979). Feuerstein has demonstrated quite remarkable success in modifying cognitive ability by using a "learning to learn" approach to the teaching of basic skills, such as classification, which children lack.

4. In view of the findings of the present investigation, the author would recommend a replication of the study with several changes:

   (a) changes in the test battery, involving omission of the Null Class task and consideration of the inclusion of a matrices task;

   (b) administration of the test battery to a larger population of both achieving and learning disabled children aged five to 16 years;

   (c) an attempt to document perceptual and linguistic problems thought to be contributing to the difficulties experienced by the learning disabled children, thereby reducing the heterogeneity of the sample population;

   (d) grouping the achieving and learning disabled children according to the number of classification tasks mastered;

(e) random sampling of equal numbers of children from the groups established in (d); and

(f) use of multivariate analysis to look for relationships between classification and memory abilities.

5. The study of the relationships which exist between various cognitive abilities is not an easy task. The author's attempt to look at memory ability in terms of "applied cognition" has made her very aware of the challenges and difficulties involved in such investigations. Research of this type is not without its rewards, however. Much insight is gained from attempting to determine how different cognitive abilities overlap, fit together and influence each other. It is recommended that such research should be encouraged and supported, since many worthwhile benefits to educators could accrue from it.

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APPENDIX A

RESULTS OF A PILOT STUDY

RESULTS OF A PILOT STUDY

Introduction

A pilot study was designed to obtain some preliminary information regarding the relationship between the operational level of the development of classification skills in achieving and learning disabled children and their total recall performance on a task in which categorization would appear to function as an appropriate mnemonic strategy for the encoding and retrieval of information. The age levels, sampling criteria, test battery and administration procedures, data collection and scoring techniques were those which would be involved in a full scale project (see Chapter V of this thesis). Cued recall scores were not obtained for children involved in the pilot study.

Five achieving and five learning disabled children were identified at each of three levels (six to seven years, eight to nine years and 10 to 11 years). Five achieving and two learning disabled children were identified at the 12 to 13 year age level. There were only two learning disabled children of the 12 to 13 age group enrolled in the school assigned to the experimenter for the pilot study. Table 20 contains a description of the sex, chronological age and IQ characteristics of the sample population.

The test battery was administered in the manner described in Appendix B of this thesis. Analysis of data yielded the following results with respect to Piagetian task performance and memory task performance.

Table 20

Description of Sex, Chronological Age, and Verbal IQ Characteristics of Pilot Study Subjects

Group	Sex		Chronological Age		Verbal IQ*		Total
	M	F	Range (months)	Mean (months)	Range	Mean	N
Achievers	3	2	72- 80	76.4	113-143	124.8	5
	2	3	96-112	103.4	108-126	114.8	5
	1	4	122-129	125.8	104-116	109.6	5
	2	3	153-161	156.6	127-145	133.6	5
Learning Disabled	2	3	68- 94	76.2	101-111	104.6	5
	3	2	100-116	109.2	88-121	102.6	5
	5	0	122-131	125.4	86-123	104.4	5
	2	0	144-146	145.0	96-103	99.5	2

* Peabody Picture Vocabulary Test - This was the only common IQ score available for all the subjects.

Piagetian Task Performance

The percentages of achieving and learning disabled children at each age level who demonstrated pre-operational, concrete operational and formal operational (where applicable) performance on each of the five Piagetian tasks were calculated and are found in Tables 21 and 22, respectively. The results presented in Tables 21 and 22 indicate that the five concepts have developed earlier in the achieving children than in the learning disabled children.

Table 21

Percentages of Pilot Study Achieving Children Demonstrating Pre-operational, Concrete Operational and Formal Operational Performance on Five Piagetian Tasks

Age Level (years)	N	Additive Composition		All and Some		Singular Class		Null Class			Duality Principle		
		PO*	CO*	PO	CO	PO	CO	PO	CO	FO*	CO	PO	FO
6- 7	5	20	80	80	20	80	20	60	-	40	100	-	-
8- 9	5	-	100	80	20	80	20	20	20	60	40	40	20
10-11	5	-	100	-	100	60	40	-	40	60	-	80	20
12-13	5	-	100	-	100	-	100	-	-	100	-	-	100

* PO = pre-operational; CO = concrete operational; FO = formal operational

Table 22

Percentages of Pilot Study Learning Disabled Children Demonstrating Pre-Operational, Concrete Operational and Formal Operational Performance on Five Piagetian Tasks

Age Level (years)	N	Additive Composition		All and Some		Singular Class		Null Class			Duality Principle		
		PO*	CO*	PO	CO	PO	CO	PO	CO	FO*	PO	CO	FO
6- 7	5	100	-	100	-	100	-	100	-	-	100	-	-
8- 9	5	80	20	100	-	100	-	100	-	-	100	-	-
10-11	5	60	40	20	80	80	20	80	-	20	100	-	-
12-13	2	-	100	50	50	-	100	100	-	-	100	-	-

*PO = pre-operational; CO = concrete operational; FO = formal operational

The inability of the learning disabled children to handle the complex class hierarchy and the inclusion relations between the levels of the hierarchy of the Duality Principle task was not unexpected (Kirkbride, 1977). The failure of all the learning disabled children (except one) to demonstrate any operational performance on the Null Class task is puzzling. The logic of posing this task as an instance of an "empty" class is questionable. It seems to involve some type of concept, however, that the learning disabled children cannot deal with. It is also puzzling that some of the achieving children demonstrate formal operational thought with respect to the Null Class task before they are concrete operational on some of the other Piagetian tasks.

Memory Task Performance

The recall means for the responses given by achieving and learning disabled children on the levels of processing memory task were calculated and are found in Table 23. The category recall means obtained by achieving and learning disabled children during their interviews are also presented in Table 23. On the levels of processing task both the achieving and learning disabled children demonstrate a developmental trend in recall ability from age level six to seven years to age level 10 to 11 years (See Table 23). Beyond the latter age level, recall appears to stabilize or fluctuate slightly. The total recall of achievers is superior to that of learning disabled children at the same age level.

Achieving and learning disabled children at all age levels

Table 23

Recall Means for Three Levels of Processing, Total Recall and Category Recall by Children Participating in Pilot Study

Group	Age Mean (in months)	Levels of Processing				Categories Recalled
		Physical	Phonemic	Semantic	Total Recall	
Achievers	76.4	1.8	1.2	4.0	7.0	1.6
	103.4	2.6	3.0	5.0	10.6	3.6
	125.8	3.4	3.0	7.2	13.6	5.4
	156.6	2.4	3.8	6.6	12.8	4.8
Learning Disabled	76.2	1.8	0.4	3.4	5.6	0.2
	109.2	1.2	1.4	4.0	6.6	0.6
	125.4	2.6	1.8	4.6	9.0	2.0
	145.0	2.0	1.5	5.5	9.0	2.0

recalled most words on the levels of processing task which had been processed at the semantic level. This finding would support Craik and Lockhart (1972). Recall of phonemic level words, however, was not superior to recall of physical level words in all cases (See Table 23). This finding does not support Craik and Lockhart (1972) but is in agreement with the findings of Kirkbride (1978a).

At all age levels, the achievers reported using more categories as retrieval cues on the memory task than learning disabled children. There also appears to be a developmental trend in both groups, with respect to the use of categories as retrieval cues up to age level 10 to 11 years and then the usage tends to stabilize or fluctuate. Increasing levels of recall seem to be associated with increasing use of categories as retrieval cues.

Conclusions

The general overall conclusion drawn from this pilot study was that the total recall ability of children with well developed classification skills was superior to that of children with less well developed classification skills. This was true within diagnostic groups, i.e., achieving and learning disabled children, and between diagnostic groups. Children who recalled more words also reported (in their interviews) that they had used more categories as retrieval cues. Achieving children demonstrated better developed classification skills and better recall ability than did learning disabled children at the same age level.

It is suggested that the method described in this pilot study

would provide a profitable approach to the study of the relationship between the development of a cognitive skill (classification) and memory ability in achieving and learning disabled children.

APPENDIX B

THE TEST BATTERY

NAME: ____________________ SCHOOL: _________________ DATE: _______

ADDITIVE COMPOSITION OF CLASSES

Material: Twenty round wooden beads; 18 red and 2 white, a sheet of yellow paper, 2 boxes. A second complete set of wooden beads (18 red, 2 white) to use if S has to make the necklaces.

Training: Present a complete set of twenty beads laid out in disorder on the sheet of yellow paper. Instruct S to pick up some of the beads and look at them. Ask,

"WHAT ARE THEY?" ________ "WHAT ARE THE BEADS MADE OF?" __________

"WHAT COLOR ARE THEY?" ______________________

"IF I PUT THE RED BEADS IN THIS BOX, WILL THERE BE ANY BEADS

LEFT?" ________

"SHOW ME WHAT WILL BE LEFT." _____________ "AND IF I PUT THE WOODEN BEADS IN THE OTHER BOX, WILL THERE BE ANY BEADS LEFT?" ___________

"WHY?" ____

If S answers no to this question ask:

"ARE THE RED BEADS MADE OF WOOD?" _________________

"ARE THE WHITE BEADS MADE OF WOOD?" _______________

Comment on training: Understood directions ___________

Prompting needed ____________ Doubtful if ever understood ________

Other _______________________

Testing Procedure: Say to S,

1. "IF I MADE A NECKLACE WITH ALL THE WOODEN BEADS, AND IF I MADE A NECKLACE OF ALL THE RED BEADS, WHICH NECKLACE WOULD BE LONGER?" ___________________ "WHY?" __________________________

If S answers the red necklace, ask: "BUT ARE THE RED BEADS WOODEN TOO?" ______________________________

2. "THEN IF I MADE A NECKLACE OF THE RED BEADS AND IF I MADE A NECKLACE OF THE WOODEN BEADS, WHICH NECKLACE WOULD BE LONGER?" ______________________________

   "WHY?" ______________________________

If S answers incorrectly, have him make the necklaces using the two complete sets of beads and compare them. Ask:

3. "IF I MADE A NECKLACE OF THE WOODEN BEADS, AND IF I MADE A NECKLACE OF THE RED BEADS, WHICH NECKLACE WOULD BE LONGER?"

   ____

   "WHY?" ______________________________

4. "ARE THERE MORE WOODEN BEADS OR RED BEADS?" ______________

   "WHY?" ______________________________

   Comment on training: Understood directions ______________

   Prompting needed __________ Doubtful if ever understood ______

   Other ______________________

NAME: ____________________ SCHOOL: __________________ DATE: __________

"ALL" AND "SOME" CONDITIONS OF CLASS INCLUSION

"All" and "Some" applied to shapes and colors

Material: 10 blue felt circles, 10 blue felt squares, 10 red felt squares, 10 red felt circles; 4 boxes (each group of shapes is placed in a separate box).

Testing Procedure:

Series 1: S is shown 5 blue circles with 2 red squares arranged thus: BC, RS, BC, RS, BC, BC, BC

S is asked, "WHAT BOXES DO YOU NEED TO REMAKE THIS?" ____________

"ARE YOU SURE?" Yes ___ No ___ "WHAT IS THIS (red square)?" ___

"AND THIS (blue circle)?" __________________

"WILL YOU MAKE ANOTHER ROW JUST LIKE THIS?" Correct _____________

Incorrect _____________

"LOOK AT THE ROW, ARE ALL THE CIRCLES HERE BLUE?" Yes ___ No ___

If S replies, "No, because there are red ones.", ask

"WHERE?" _______________________

"ARE ALL THE SQUARES HERE RED?" Yes ___ No ___

Series II: S is shown series II arranged thus:

BC, RS, BC, RS, BS, BC, BC, BS, BC

"WHICH BOXES DO YOU NEED TO MAKE THIS?" __________________________

"WILL YOU MAKE ANOTHER ROW JUST LIKE THIS ONE?" Correct _________

Incorrect ______________

Then S is asked to look at the row. The following questions are asked:

1. "ARE ALL THE CIRCLES BLUE?" Yes ________ No ________

2. "ARE ALL THE RED ONES SQUARES?" Yes ________ No ________

3. "ARE ALL THE BLUE ONES CIRCLES?" Yes ________ No ________

4. "ARE ALL THE SQUARES RED?" Yes ________ No ________

Comment on testing: Understood the directions ________________

Prompting needed ________________________

Doubtful if ever understood ______________

Other __________________________________

NAME:__________________SCHOOL: _______________DATE:___________

THE SINGULAR CLASS

Classification and the Relative Size of Classes

Material: 4 large blue squares (4" x 4"); 4 small blue squares (2" x 2"); 3 large blue circles (4" diameter); 4 small blue circles (2" diameter); 1 large red circle (4" diameter); for the second part of the test: 3 red objects -- a large square, a small square, a small circle.

Test Procedure: S is shown the large blue squares, small blue squares, large blue circles, small blue circles, and the large red circle. Say:

1. "PUT TOGETHER ALL THE ONES THAT GO TOGETHER."

   Record sorting ____

   ____

   If he has not already done so, S is told to "DIVIDE THE OBJECTS INTO TWO GROUPS ONLY."

   Group I: _________ "WHY DID YOU PUT THESE TOGETHER?" _______

   ____

   Group II: ________ "WHY DID YOU PUT THESE TOGETHER?" _______

   ____

2. "NOW I WANT YOU TO DIVIDE THE OBJECTS INTO TWO GROUPS AGAIN, ONLY THIS TIME USE A DIFFERENT WAY. THE FIRST TIME YOU USED ________________________. NOW THINK OF ANOTHER WAY TO DIVIDE THE OBJECTS."

   Group I: _________ "WHY DID YOU PUT THESE TOGETHER?" _______

   ____

   Group II:_________ "WHY DID YOU PUT THESE TOGETHER?" _______

   ____

   S is unable to think of a second criterion for sorting _____

3. "THIS TIME I WANT YOU TO USE A THIRD WAY TO DIVIDE THE OBJECTS. FIRST YOU USED ____________ THEN YOU USED ________ ________. NOW THINK OF A THIRD WAY."

Group I: ____________ "WHY DID YOU PUT THESE TOGETHER?" ____

____

Group II: ____________ "WHY DID YOU PUT THESE TOGETHER?" ____

____

S is unable to think of a third way to sort ______________

4. Add the red elements: a large square, a small square, and a small circle.

"NOW CAN YOU DIVIDE THE OBJECTS INTO TWO GROUPS." If he now sorts by color, where previously he did not, ask: "WHY DIDN'T YOU DO THAT BEFORE? WHY DIDN'T YOU PUT THE RED ONES IN ONE PILE AND THE BLUE ONES IN ANOTHER?"

____

____

Comment on testing: Understood the directions ____________

Prompting needed ____________________

Doubtful if ever understood __________

Other ______________________________

NAME:____________________ SCHOOL:__________________ DATE:____________

THE NULL CLASS

Material: 6 white cardboard circles, 2" diameter; 6 white cardboard squares, 2" sides; 6 white cardboard equilateral triangles, 2" sides. Half of each group of cards are blank, the rest have pictures of shoes, cars and cherries on them, one picture of each item on each shape of card, i.e., a circle with a shoe, a circle with a car, a circle with a bunch of cherries, etc.

Testing Procedure: Present all the cards to S in disarray, and give the following instructions:

1. "PUT THE CARDS TOGETHER THAT GO TOGETHER, THE ONES THAT BELONG TOGETHER."

   Describe the sorting: ______________________________

   ____

2. "THIS TIME I WANT YOU TO PUT TOGETHER THE CARDS THAT BELONG TOGETHER AND I WANT YOU TO MAKE TWO PILES ONLY."

   Pile 1: ____

   Pile 2: ____

   Any cards not sorted? Yes ____________ No ____________

   Describe the remainder ______________________________

   "WHAT ARE YOU GOING TO DO WITH THESE?" __________________

   Comment on testing: Understood the directions ____________

   Prompting needed __________________

   Doubtful if ever understood __________

   Other __________________________

NAME:____________________ SCHOOL:__________________ DATE:____________

THE DUALITY PRINCIPLE

Material: Pictures, 2" x 2"; 5 different animals (cow, horse, pig, lamb, dog), 3 birds not ducks, 3 ducks.

Training: Present S with the material and say, "HERE ARE SOME PICTURES."

"THIS (indicate duck) IS A" _____________________________________?

"THIS (indicate bird not duck) IS A" ____________________________?

"WHAT KINDS OF BIRDS (indicate the birds which are not ducks) ARE THESE?" ________________, _________________, __________________.

"HOW ARE THESE THREE (indicate ducks) ALIKE?" _____________________

"HOW ARE THESE THREE (indicate birds not ducks) ALIKE?" __________

"ARE THESE (indicate ducks) LIKE THESE (indicate birds not ducks) IN ANY WAY?" ____

If the response is not forthcoming, say: "DID YOU KNOW THAT DUCKS ARE BIRDS?" __________________________

"COULD WE MAKE ONE GROUP USING BOTH OF THESE LITTLE GROUPS?" (indicate groups of ducks and group of birds not ducks)

__________________________________ "WHY?" ___________________________

"ARE THE DUCKS BIRDS?" _________ "WHY?" ___________________________

"ARE THE DUCKS ANIMALS?" _______ "WHY?" ___________________________

"ARE THE BIRDS ANIMALS?" _______ "WHY?" ___________________________

Comments: Understood questions ___________________________________

Prompting needed _______________________________________

Doubtful if ever understood ______________________________

Other ____

Test Procedure:

1. Spontaneous classification. Present S with material and say,

"CAN YOU MAKE SOME GROUPS WITH ANIMALS THAT ARE LIKE EACH OTHER? FIND THE ANIMALS THAT ARE THE SAME KIND TWO OR MORE TIMES AND PUT THEM TOGETHER."

Description of classification ______________________________

____

"DIVIDE THE PICTURES INTO BIRDS AND OTHER ANIMALS."

Birds ____

Other Animals ______________________________________

"DIVIDE THESE (indicate birds) INTO DUCKS AND OTHER BIRDS."

Ducks ____________________ Other Birds ______________________

2. General questions on inclusion:

"ARE THERE MORE BIRDS OR MORE ANIMALS?" __________________

"WHY" ____

If S answers "more birds" or "it is the same," ask "BUT IF ONE COUNTS ALL THE BIRDS AND THEN COUNTS ALL THE ANIMALS, WHERE WILL THERE BE MORE?"

More birds __________ More animals ___________ "WHY?" ________

"ARE THERE MORE DUCKS OR MORE BIRDS?" More ducks ___________

More birds ____________

"WHY ARE THERE MORE (___________)?" __________________________

If S answers that "it is the same", ask "BUT IF ONE COUNTS ALL THE DUCKS AND THEN COUNTS ALL THE BIRDS, WHERE WILL THERE BE MORE?"

More ducks _________ More birds _____________ "WHY?" _________

3. Questions on the Duality Principle:

"SHOW ME ALL THE THINGS WHICH ARE NOT DUCKS, AND ALL THOSE WHICH ARE NOT BIRDS."

Not ducks ________________ Not birds ____________________

"SHOW ME ALL THE THINGS WHICH ARE NOT BIRDS, AND ALL THOSE WHICH ARE NOT ANIMALS."

Not birds ________________ Not animals ____________________

"ARE THERE MORE LIVING THINGS WHICH ARE NOT DUCKS OR MORE LIVING THINGS WHICH ARE NOT BIRDS?"

More which are not ducks ________________

More which are not birds ________________

"WHY ARE THERE MORE WHICH ARE NOT (________)?" ____________

"ARE THERE MORE LIVING THINGS WHICH ARE NOT BIRDS OR MORE LIVING THINGS WHICH ARE NOT ANIMALS?"

More which are not birds ________________

More which are not animals ________________

"WHY ARE THERE MORE WHICH ARE NOT (________)?" ____________

4. If S has difficulty with form (2) or (3) questions, ask the following questions involving subtraction or negation:

"IF ALL THE DUCKS IN THE WORLD WERE KILLED, WOULD THERE BE ANY BIRDS LEFT?"

Yes ____________ No ____________ "WHY?" ____________________

"IF ALL THE BIRDS IN THE WORLD WERE KILLED, WOULD THERE BE ANY DUCKS LEFT?"

Yes ____________ No ____________ "WHY?" ____________________

"IF ALL THE ANIMALS IN THE WORLD WERE KILLED, WOULD THERE BE ANY BIRDS LEFT?"

Yes ____________ No ____________ "WHY?" ____________________

"IF ALL THE BIRDS IN THE WORLD WERE KILLED, WOULD THERE BE ANY ANIMALS LEFT?"

Yes ____________ No _____________ "WHY?" ______________________

Comments: Understood questions ______________________________

Prompting needed ______________________________

Doubtful if ever understood ______________________________

Other ______________________________

Test Procedure:

1. Spontaneous classification. Present S with material and say:

   "MAKE SOME GROUPS WITH THE FLOWERS THAT ARE LIKE EACH OTHER. FIND THE FLOWERS THAT ARE THE SAME KIND TWO OR MORE TIMES AND PUT THEM TOGETHER." Description ____________

   "DIVIDE THE PICTURES INTO ROSES AND OTHER FLOWERS."

   Roses ____________ Other flowers ____________

   "DIVIDE THESE (roses) INTO RED ROSES AND OTHER ROSES." Red Roses ____________ Other roses ____________

2. General questions on inclusion.

   "ARE THERE MORE ROSES OR MORE FLOWERS?" ________ "WHY?" ________

   If S answers roses or the same, ask: "BUT IF ONE COUNTS ALL THE ROSES AND THEN COUNTS ALL THE FLOWERS, WHERE WILL THERE BE MORE?" More roses ________ More flowers ________ "WHY?" ________

   "ARE THERE MORE RED ROSES OR MORE ROSES?" More red roses ________ More roses ________ "WHY?" ________

   If S answers "the same", ask "BUT IF ONE COUNTS ALL THE RED ROSES AND THEN COUNTS ALL THE ROSES, WHERE WILL THERE BE MORE?"

   More red roses ________ More roses ________ "WHY?" ________

3. Questions on the Duality Principle.

   "SHOW ME ALL THE THINGS WHICH ARE NOT RED ROSES, AND ALL THOSE WHICH ARE NOT ROSES." Not red roses ________ Not roses ________

   "SHOW ME ALL THE THINGS WHICH ARE NOT ROSES, AND ALL THOSE WHICH ARE NOT FLOWERS." Not roses ________ Not flowers ________

   "ARE THERE MORE LIVING THINGS WHICH ARE NOT RED ROSES OR MORE

LIVING THINGS WHICH ARE NOT ROSES?" Not red roses ____________

Not roses ____________ "WHY?" ____________________________________

"ARE THERE MORE LIVING THINGS WHICH ARE NOT ROSES OR MORE

LIVING THINGS WHICH ARE NOT FLOWERS?" Not roses __________ Not

flowers __________ "WHY?" ______________________________________

4. Questions on subtraction or negation of classes.

"IF ALL THE RED ROSES IN THE GARDEN WERE PICKED, WOULD THERE BE

ANY ROSES LEFT?" Yes __________ No __________ "WHY?" __________

"IF ALL THE ROSES IN THE GARDEN WERE PICKED, WOULD THERE BE ANY

RED ROSES LEFT?" Yes __________ No __________ "WHY?" __________

"IF ALL THE FLOWERS IN THE GARDEN WERE PICKED, WOULD THERE BE

ANY ROSES LEFT?" Yes __________ No __________ "WHY?" __________

"IF ALL THE ROSES IN A GARDEN WERE PICKED, WOULD THERE BE ANY

FLOWERS LEFT?" Yes __________ No __________ "WHY?" __________

Comments: Understood questions ________________________________

Prompting needed ____________________________________

Doubtful if every understood ________________________

Other ____

NAME: ________________ SCHOOL:________________ DATE: ____________

LEVELS OF PROCESSING MEMORY TASK

Material: A series of six orienting questions and stimulus words to be used during the training session and a series of thirty orienting questions and stimulus words to be used during the test session. Each question and each stimulus word is printed in large type on a separate card (3 inches x 5 inches).

Procedure: The subject is told that he will be shown and read a series of questions and words. He is to reply "Yes" or "No" to the question about each word. When all of the questions have been answered, he will be asked to recall as many of the words as possible. The examiner shows the subject the card containing the orienting question and simultaneously reads the question to him. The question card is then placed face down on the table. The experimenter immediately shows the subject the card containing the stimulus word and simultaneously reads the word to him. The subject's "Yes" or "No" responses are recorded by the experimenter. The training session is conducted to ensure that the subject understands the procedure. Immediately following the last trial of the experiment, the experimenter says to the subject, "Please tell me all the words that you can remember." The subject's responses are recorded verbatim. Following the free recall test, the experimenter asks the subject how he has remembered the words reported on the recall test. The subject's responses are recorded, and any item categories mentioned are noted. Finally, any categories not mentioned by the subject are suggested by the experimenter and a cued recall score is thus obtained.

ALTERNATIVE FORM OF DUALITY PRINCIPLE (FLOWER CLASSIFICATION)

Material: Pictures, 2" x 2"; 5 different flowers other than roses; 3 red roses, 3 roses of 3 different colors other than red.

Training: Present S with material and say: "HERE ARE SOME PICTURES."

"THIS (indicate red rose) IS A" ______________________________?

"THIS (indicate rose not red) IS A" ____________________________?

"WHAT KINDS OF ROSES (indicate roses not red) ARE THESE? __________,

_____________________, ______________________________.

"HOW ARE THESE THREE (indicate red roses) ALIKE?" ______________

"HOW ARE THESE THREE (indicate roses not red) ALIKE?" ___________

"ARE THESE (indicate red roses) LIKE THESE (indicate roses not red)

IN ANY WAY?" ____

If the response is not forthcoming, say: "DID YOU KNOW THAT RED

ROSES AND ROSES OF OTHER COLORS ARE ALL ROSES?" _______________.

"COULD WE MAKE ONE GROUP USING BOTH OF THESE LITTLE GROUPS?"

(indicate red roses and roses not red) ___________________

"WHY?" ____.

"ARE THE RED ROSES ROSES?" __________ "WHY?" ______________

"ARE THE RED ROSES FLOWERS?" ________ "WHY?" ______________

"ARE THE ROSES FLOWERS?" ___________ "WHY?" ______________

Comments: Understood questions ______________________

Prompting needed ________________________

Doubtful if understood ___________________

Other _______________________________

Orienting Questions and Stimulus Words for Levels of Processing Memory Task

Orienting Question	Stimulus Word	Response	Level of Processing
Training Session			
A. Does this word rhyme with card?	Tire		Phonemic
B. Does this word mean a type of vehicle?	Fence		Semantic
C. Does this word start with a "T"?	Trout		Physical
D. Does this word rhyme with three?	Moan		Phonemic
E. Does this word end with a "P"?	Sheep		Physical
F. Does this word mean a type of fruit?	Apple		Semantic
Test Session			
1. Does this word rhyme with hunter?	Carrot		Phonemic
2. Does this word start with a "T"?	Orange		Physical
3. Does this word end with a "P"?	Corn		Physical
4. Does this word rhyme with shed?	Bed		Phonemic
5. Does this word mean a type of weapon?	Knife		Semantic
6. Does this word mean a type of fruit?	Peach		Semantic
7. Does this word rhyme with star?	Dress		Phonemic

Orienting Question	Stimulus Word	Response	Level of Processing
8. Does this word mean a type of fruit?	Shirt		Semantic
9. Does this word mean a type of vehicle?	Chair		Semantic
10. Does this word start with a "G"?	Gun		Physical
11. Does this word end with an "N"?	Train		Physical
12. Does this word rhyme with fuss?	Bus		Phonemic
13. Does this word start with a "B"?	Rifle		Physical
14. Does this word mean a type of clothing?	Couch		Semantic
15. Does this word rhyme with radio?	Lettuce		Phonemic
16. Does this word mean a type of vehicle?	Skirt		Semantic
17. Does this word rhyme with book?	Desk		Phonemic
18. Does this word start with a "C"?	Car		Physical
19. Does this word mean a type of furniture?	Banana		Semantic
20. Does this word end with an "E"?	Apple		Physical
21. Does this word rhyme with sheep?	Jeep		Phonemic
22. Does this word mean a type of vehicle?	Taxi		Semantic
23. Does this word start with a "C"?	Sword		Physical

Orienting Question	Stimulus Word	Response	Level of Processing
24. Does this word end with a "Z"?	Pear		Physical
25. Does this word mean a type of weapon?	Bomb		Semantic
26. Does this word start with a "B"?	Blouse		Physical
27. Does this word rhyme with boat?	Coat		Phonemic
28. Does this word rhyme with stable?	Table		Phonemic
29. Does this word mean a type of vegetable?	Tomato		Semantic
30. Does this word rhyme with sky?	Pea		Phonemic

Note: The phonemic and two of the semantic orienting questions were rephrased for use with the youngest groups of children. In the phonemic questions the words "sound like" were substituted for "rhyme with." With respect to the semantic questions "something to ride in" was substituted for "vehicle" or "something to fight with" was substituted for "weapon."

APPENDIX C

CRITERIA FOR PLACEMENT IN THE DEVELOPMENTAL STAGES OF THE PIAGETIAN TASKS

Additive Composition of Classes

Stage 1: Absence of Additive Composition.

The subject does not understand that the B class (wooden beads) will always contain more elements than the A (red beads) and A' (white beads) classes. He does not think simultaneously of the whole B and the parts A and A'. There is no understanding that B = A + A' and that A = B - A'. Even when the subject makes and compares the necklaces, this is not understood.

Stage 2: Intuitive stage.

The subject gradually realizes that the B class (wooden beads) contains more elements than either the A (red beads) or A' (white beads) classes. This intuitive discovery is made only when the subject is compelled to make the necklaces and to visualize the sets. He finds that the B (wooden beads) class is larger than the A (red beads) class but he does not assume this fact because of the inclusions resulting from additive composition.

Stage 3: Concrete operations.

The subject immediately grasps that class B (wooden beads) is larger than class A (red beads) and can explain his answer in terms of additive composition.

"All" and "Some" Conditions of Class Inclusion

Stage 1: Graphic collections.

Even Series I which deals with only two kinds of elements, blue circles and red squares, is too difficult. The subject may have difficulty selecting the correct elements with which to reproduce the series. Most answers to the inclusion questions are wrong.

Stage 2: Non-graphic collections.

The subject can deal with the Series I and answer the questions related to it correctly. Problems are encountered with Series II which involves three kinds of elements, blue circles, blue squares and red squares. The subject cannot answer all of the inclusion questions correctly. Usually more difficulty is experienced with questions which ask are all the A's B's?, i.e., "Are all of the circles blue?" than with questions which ask are all the B's A's?, i.e., "Are all the blue ones circles?"

Stage 3: Concrete operations.

The subject understands the use of the logical quantifiers "all" and "some". All of the questions are answered correctly.

The Singular Class

Stage 1:

The subject treats the large red circle or the "unique element" like the rest of the objects or ignores it completely. Stage 1 was divided into two substages for the purpose of this investigation:

Stage 1a: The subject classifies the objects on the basis of shape only.

Stage 1b: The subject classifies the objects on the basis of shape and size only.

Stage 2:

The subject sorts the objects on the basis of size and shape. A classification based on color is produced only after the additional red objects are presented and not before.

Stage 3: Concrete operations.

The subject spontaneously sorts the objects on the basis of size, shape and color. The singular class is recognized and constructed immediately.

The Null Class

Stage 1: Graphic collections.

The subject forms graphic collections from the cards.

Stage 2: Non-graphic collections

The subject forms non-graphic collections from the cards. Sorting may be done on the basis of shape, objects or color, in the latter case the blank cards are considered white.

Stage 3: Concrete operations.

The subject can be led to produce the correct division of cards into two groups, i.e., cards with pictures and cards without pictures, only with the help of the examiner.

Stage 4a: Initial stage of formal operations.

The subject spontaneously divides the cards into two groups, i.e., cards with pictures and cards without pictures.

The Duality Principle

Stage 1: Spontaneous classification.

The subject correctly sorts the classes ducks, birds not ducks, and animals not birds, but answers all the questions incorrectly.

Stage 2: Non-graphic collections.

The subject correctly sorts the classes ducks, birds not ducks, and animals not birds, and answers the questions dealing with negation of classes correctly. Answers to all the other questions are incorrect.

Stage 3: Concrete operations.

The subject succeeds with the questions on the quantification of inclusion and negation of classes, but fails with the questions on the Duality Principle.

Stage 4: Formal operations.

The subject answers all the questions correctly including the questions on the Duality Principle. The relationship between the ordering of classes and the ordering of their complements as expressed by: $(A) < (B) \rightarrow (\text{not-}A) > (\text{not-}B)$ is understood.

The Duality Principle
(Alternative Form: Flower Classification)

Stage 1: Spontaneous classification.

The subject correctly sorts the classes red roses, roses of colors other than red, and flowers not roses, but answers all the questions incorrectly.

Stage 2: Non-graphic collections.

The subject correctly sorts the classes red roses, roses of colors other than red, and flowers not roses, and answers the questions dealing with negation of classes correctly. Answers to all the other questions are incorrect.

Stage 3: Concrete operations.

The subject succeeds with the questions on the quantification inclusion and negation of classes, but fails with the questions on the Duality Principle.

Stage 4: Formal operations.

The subject answers all the questions correctly including the questions on the Duality Principle. The relationship between the ordering of classes and the order of their complements as expressed by: (A) < (B) → (not-A) > (not-B) is understood.